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The Relative Effectiveness of Course Delivery Methodology on Student Success, Retention, and Persistence in Remedial Mathematics

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THE RELATIVE EFFECTIVENESS OF COURSE DELIVERY METHODOLOGY ON STUDENT SUCCESS, RETENTION AND PERSISTENCE IN REMEDIAL MATHEMATICS

by

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Abstract Page

There are a substantial number of studies that consider the effectiveness of online instructional methodologies in general, but there is sparse previous work specifically targeting developmental mathematics students in community colleges. This study examines the relative effectiveness of online versus traditionally delivered developmental mathematics courses at Somerset Community College (SCC) in Somerset, Kentucky. At SCC, developmental mathematics is divided into three consecutive courses, MAT 055, MAT 065, and MAT 085, and this study considered each of these courses separately.

For this study, each student enrollment in any of SCC's developmental mathematics courses was obtained for students in the Fall 2011 through the Spring 2016 semesters. This population consisted of 9,400 anonymous students, which accounted for 20,365 individual course enrollments. The data obtained included demographic data, course grade information, and the last date attendance for students who failed the class. The data were statistically analyzed to determine the relative effect of course delivery methodologies with the population trimmed along a variety of demographic variables. In addition, the rate of student retention and persistence through the developmental mathematics sequence was also statistically analyzed.

This analysis, consistent with findings in previous studies, indicated that online delivery methodologies can be at least as effective as face-to-face delivery methodologies for all groups of students as measured by student grades. With regards to non-grade measures of student success such as retention and persistence, however, online courses did not fare as well as traditionally delivered sections. These mixed results suggest the overall value of online course offerings for developmental mathematics courses, but educational leaders must be aware of and work to account for the relative weaknesses of online delivery methodologies.

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Chapter 1

Introduction

Technological advances have increased the speed and diversity of communication and travel, and these changes have resulted in business' outsourcing manufacturing and, at an increasing rate, white-collar jobs to advantageous markets with lower labor costs (Johnson & Kasarda, 2008). These changes require American workers to develop a deeper and more flexible understanding of science, technology, engineering, and mathematics (STEM) concepts in order to be globally competitive and capable of the continuous learning that is necessary to evolve with an ever-changing economic reality (Johnson & Kasarda, 2008; Stewart, 2005). The need in the global economy for greater understanding of STEM concepts, therefore, makes it critical that educational leaders provide STEM learning opportunities for traditional and non-traditional students, even those who are under-qualified or unable to participate in traditional course structures because of other life situations.

In the years since the publication of *The No Significant Difference Phenomenon* in 1999, which found that there was not a significant difference in student performance between traditional and distance education courses, online course offerings are commonly being used to increase student opportunities for higher education without requiring brick-and-mortar investment (Lyke & Frank, 2012; Nguyen, 2015; Russell, 1999). Online courses are a cost-effective alternative allowing schools to serve more students, and enrollment in these courses is growing. More than 30% of students take some online courses, and online courses have a significantly higher growth rate than traditional courses (Driscoll, Jicha, Hunt, Tichavsky, & Thompson, 2012). There is a diverse body of research comparing student performance and satisfaction between online and traditional settings, and there is substantial yet conflicted evidence suggesting similar student achievement but lower student satisfaction in online courses (Ashby, Sadera, & McNary, 2011; Lyke & Frank, 2012; Nguyen, 2015; Summers, Waigandt, & Whittaker, 2005).

Economic realities, which drive more students into institutions of higher education, will necessarily increase the number of under-qualified students, and this eventuality is evident in enrollment data. Between 15% and 22% of first-year students in postsecondary institutions enroll in remedial mathematics courses, and this number can be substantially higher for community college students. Furthermore, the rate of successful completion in these remedial courses can be below 50% (J. M. Wenner, Burn, & Baer, 2011). Such a completion rate for these courses is particularly troubling when considered alongside studies that suggest successful completion of courses in the first semester of college, when many students are taking remedial courses, is positively related to eventual completion of a degree program (Frantzen, 2014).

Continued student struggles in remedial mathematics courses, coupled with common student difficulties in applying mathematical concepts to non-mathematical disciplines, has led to the rise of creatively embedded mathematical instruction within other disciplines. One such effort, which was funded by the National Science Foundation, is a project called *The Math You Need When You Need It (TMYN).* TMYN uses individual student modules to instruct students in specific mathematical content as it is used within other courses (J. Wenner & Baer, 2015; J. M. Wenner et al., 2011). Though such a just-in-time effort is commendable, its very existence speaks to a broader issue with the overall state of mathematics education. The topics contained in the program's modules, such as unit conversions, slope, graphing, and rearranging equations, are standard College Algebra topics, which commonly comprise the minimum standard mathematics course for college students (J. M. Wenner et al., 2011). Due to a number of factors, including weaknesses in K-12 student preparation, curriculum concerns, and the number of years removed from the formal classroom for many non-traditional students, students continue to demonstrate poor mathematical skills, habits, and abilities to generalize understandings even after completing College Algebra (J. Wenner & Baer, 2015; J. M. Wenner et al., 2011).

Considered holistically, the increased number of college students testing into remedial mathematics courses suggests that research into student achievement and perseverance in remedial mathematics courses is an important venture for educational leaders. While the asynchronous and individualized learning opportunities provided through online platforms are attractive to students, as measured by the increased enrollments, an ethical obligation falls upon leaders to not provide educational opportunities to students, especially which result in personal debt, that have not been shown to be effective. Educational leaders do not fulfill ethical obligations to students without actively working to ensure that the educational opportunities are effective, beneficial, and efficient for students (Cooper, 2004). Remedial programs must provide students with a reasonable expectation of educational success.

Though there is substantial research into the effectiveness of online instruction in general, not all courses and disciplines are well-researched. While there is research focused on online mathematics courses, little of it focuses on remedial courses or community college students (Ashby et al., 2011). In addition, there remains little research into the impact of technologically dependent instruction on non-traditional student populations (Frantzen, 2014). This research aims to address some of these issues by studying students at one of the Kentucky Community and Technical College Systems' (KCTCS) schools, Somerset Community College (SCC) in Somerset, Kentucky.

Context

Prior to 1997, the state's community colleges were governed by the University of Kentucky and the technical colleges were under the leadership of the Cabinet for Workforce Development, but these were, excluding Lexington Community College (LCC), consolidated into KCTCS (*Summary of House Bill 1 as enacted*, 1997). LCC was later added to the system, and KCTCS is now composed of 16 colleges on 70 campuses serving over 80,000 students in some capacity across the state. While the initial emphasis on general education remains, KCTCS has increased higher education enrollment in the state as well as enhanced the level of completion of a variety of credentials. In 2015 alone, the system awarded over 9600 associate degrees and more than 30,000 total credentials ("KCTCS," n.d.).

Somerset Community College, which is located in southcentral Kentucky, is one of KCTCS' 16 colleges. In the Fall 2015 semester, SCC had an enrollment of 6,410 total students, 4,832 of whom were taking distance education courses ("Somerset Community College," 2016). As measured by total credit hours earned, with over 59,000 hours earned, SCC is the third largest school in KCTCS behind Jefferson Community and Technical College (CTC) in Louisville, KY and Bluegrass CTC in Lexington, KY. In addition, 46.7% of SCC's student are classified as full-time; this is also the third highest rate in the system behind Ashland CTC and Southeast Kentucky CTC ("Fall Enrollment," n.d.).

A substantial majority of SCC's students, 59.8%, are female, and the college's students are also predominantly, 93.4%, white ("Somerset Community College," 2016). The predominance of white students at SCC is above the KCTCS average of 80.31%, but it is consistent with the surrounding community which is 94.6% white ("Somerset Community College," 2016; U.S. Census Bureau, n.d.).

A primary motivating force behind the selection of SCC as the college for this study is the magnitude of the school's remedial mathematics and distance education programs. At KCTCS schools, remedial mathematics is divided into three courses: Pre-Algebra (MAT 055), Basic Algebra (MAT 065), and Intermediate Algebra (MAT 085). In the Fall 2016 semester, SCC offered 30 sections of Pre-Algebra (three online), 30 sections of Basic Algebra (three online), and 31 sections of Intermediate Algebra (four online) ("Somerset Community College," 2016).

Purpose of the Study

The purpose of this study is to consider the relative effectiveness of online and traditional delivery methods of remedial mathematics courses. Effectiveness will be measured by course grade, the rate of course completion, student retention from one semester to the next, and student persistence to earn a college-level mathematics credit. Course grade serves as a proxy for academic achievement, and course completion, retention and persistence provide insight into the effectiveness of the remedial program as an entry point into higher education. There are certainly weaknesses in using course grade as a proxy for academic achievement, but it is accessible data and a common metric in similar research. Therefore, the limitations in using this data are superseded by other factors (Driscoll et al., 2012).

Perspective Guiding Research

This research is built upon a foundation of studies addressing related, but different, issues in distance education and student retention (Ashby et al., 2011; Driscoll et al., 2012; Fike & Fike, 2008; Lyke & Frank, 2012; McCall, Dunham, & Lyons, 2013; Summers et al., 2005). Ashby and McNary's (2011) study is the most directly connected to the goal of this work in that it considered developmental mathematics at community colleges, and it contradicted previous research findings of no significant difference in student achievement between online and face-to-face delivered courses. This contradiction suggested value in a similar study of remedial mathematics students. Other than this study, the other studies considering the difference in student achievement based on delivery methods were either not limited to online and traditional courses only, in other disciplines, or in other types of higher education institutions (Castle & McGuire, 2010; Driscoll et al., 2012; Lyke & Frank, 2012; Summers et al., 2005). These studies, though, provided a useful perspective for designing this study.

Though student achievement is of primary concern, course completion, student retention and persistence are also critically important topics of study for educational leaders, and this importance is magnified in the community college environment, which is known to have higher student attrition rates than other higher educational institutions (Ashby et al., 2011; Fike & Fike, 2008).

Research Questions

The primary research question is: *How does student achievement, retention, and persistence compare in remedial mathematics courses between online and traditional delivery methods?* The following questions, though, will be used to guide the research and provide clarity, insight, and nuance into the primary question.

Research Questions

1. Is there a significant difference in the distribution of course grades, considering MAT 055, MAT 065, and MAT 085 independently, between remedial mathematics courses taught using online versus traditional methods?
2. Is there a significant difference in the distribution of course grades, considering MAT 055, MAT 065, and MAT 085 independently, between remedial mathematics courses

taught using online versus traditional methods if only students who complete the course are considered?

3. Is there a significant difference in the distribution of course grades, considering MAT 055, MAT 065, and MAT 085 independently, between remedial mathematics courses taught using online versus traditional methods for traditional and non-traditional students?
4. Is there a significant difference in the distribution of course grades, considering MAT 055, MAT 065, and MAT 085 independently, between remedial mathematics courses taught using online versus traditional methods for part-time or full-time students?
5. Is there a significant difference in the proportion of students who complete remedial mathematics courses, considering MAT 005, MAT 065, and MAT 085 independently, between students taught using online versus traditional methods?
6. Is there a significant difference in the proportion of students retained in a mathematics course the following semester, considering MAT 055, MAT 065, and MAT 085 independently, between remedial mathematics courses taught using online versus traditional methods?
7. Is there a significant difference in the proportion of students who persist in earning a college-level mathematics credit between students enrolled in MAT 085 courses taught using online versus traditional methods?

Scope and Bounds

This study is specifically focused on remedial mathematics students in a single community college in Kentucky, so there is limited generalizability of the results. Having a narrowly focused study allows for a number of variables, such as curriculum, cultural background, and instructors, to be controlled for, but it also opens up other potentially confounding issues such as the quality of the classroom instructor and the quality of the online platform being utilized.

On the other hand, by following the format of several other studies at other schools in other disciplines, the results of this study have the potential to add evidence to previous findings or provide counter results. If this study supports the results of other similar studies with different populations and in other fields, then the generalizability of broader conclusions is bolstered. If, though, the results are contrary, then there is reason to continue explorations into potential dynamics of remedial mathematics which are unique and which may impact the relative effectiveness of differing delivery method.

There is growing research suggesting that mathematics education which focuses on skills is ineffective. Such instruction contributes to a dread of mathematics and lower mathematical self-efficacy particularly for women and minorities (Boaler, 2016). This research, however, is specifically targeting the relative effectiveness of the delivery method and not the curriculum itself. As such, the results are limited to relative effectiveness.

Significance of Study

The globalization of the economy has increased the importance of higher education for a larger proportion of society, and this has resulted in increasing the number of students requiring remediation, particularly in mathematics (J. M. Wenner et al., 2011). Many of these new students are non-traditional, often with children and full-time employment, so asynchronous course delivery methodologies appear to be an attractive option. A substantial body of research suggests that there is no significant difference in student achievement based on the mode of delivery; however, many of these studies are suspect and few focus particularly on remedial mathematics and community college students (Ashby et al., 2011; Driscoll et al., 2012).

There are factors unique to remedial mathematics that raise concerns about the applicability of other studies to remedial mathematics courses. Whereas traditional mathematics classrooms can accommodate more passive learning styles, online courses, particularly in mathematics, require students to take far more responsibility for their learning (Summers et al., 2005); this additional responsibility requires motivation and mathematical self-efficacy. However, the very nature of remedial mathematics courses means that students have already taken classes covering the material and been unsuccessful, at least in retaining, the mathematical content. These previous struggles tend to reduce motivation and self-efficacy (Simzar, Martinez, Rutherford, Domina, & Conley, 2015; Zeldin, Britner, & Pajares, 2008). Such a prior exposure to the content bias on the part of the student may not be a substantial issue on other general education classes, such as sociology, to which a student has little prior exposure.

A student's ability to achieve his or her professional aspirations is often predicted on the ability to earn a degree or credential in a higher education institution, and this process often begins in remedial mathematics courses. Long-term success in college is impacted by first semester classes, so studying the delivery methodology utilized in remedial mathematics courses is an important concern for educational leaders (Frantzen, 2014).

Definition of Terms

Because the following terms and abbreviations are used repeatedly in this study, it is helpful to articulate the working definition of the terms.

Course Completion – a student will be deemed to have completed a course if (1) the student earns a passing grade in the course or (2) the final date of attendance is within ten days of the end of the semester in which the course was taken.

Non-traditional student – a college student older than 24 years of age.

Online course – a course taught entirely through online platforms. There is no direct, face-to-face instruction.

Persistence – for the purposes of this study, a student will be considered to have persisted in remedial mathematics if the student earns a mathematics credit in a credit-bearing mathematics course upon successful completion of MAT 085.

Remedial mathematics course – any of three non-credit bearing college mathematics course preparing students for a credit bearing mathematics course. In regards to this study and KCTCS, the specific courses of interest are MAT 055 (Pre-Algebra), MAT 065 (Basic Algebra), and MAT 085 (Intermediate Algebra).

Retention – for the purposes of this study, a student is considered retained in remedial mathematics if the student enrolls in a mathematics course the next semester.

Traditional student – a college student between 18 and 24 years of age.

Traditional course – a college course taught using direct, face-to-face instruction from a teacher to a class of students. These classes may utilize online platforms for homework or other communication.

Summary

The growing number of remedial mathematics students in higher education combined with technological advances making online education more affordable and effective has resulted in a growth of online course offerings being made available for remedial students. The availability of online delivery methods, though, makes it incumbent on educational leaders to consider the relative effectiveness of various modes of instruction so that students are being offered educationally appropriate and sound instruction resulting in equivalent levels of achievement, retention, and persistence.

Though there is a substantial body of research attempting to make comparisons in student achievement and satisfaction between online and traditional delivery methods, few of these are focused on remedial mathematics courses (Driscoll et al., 2012). Remedial mathematics students represent an increasing group of students in higher educational institutions, and they have challenges not necessarily evident for students in other disciplines. Particularly, remedial mathematics students have, by definition, previously struggled to learn the material and, thus, may be impacted by low mathematical self-efficacy, motivation, or confidence (Boaler, 2016).

Technological advances have allowed for a variety of instructional delivery methods for remedial mathematics courses, but it is important for educational leaders to consider the relative effectiveness of various delivery methods on student achievement, retention, and persistence. This study aims to consider precisely these factors by examining remedial mathematics data from SCC. In addition to holistic effectiveness, relationships will be considered between particular demographic and behavioral patterns which may increase or decrease the likelihood of student success in online remedial mathematics courses.

Chapter 2

Literature Review

There are a wide variety of topics of research in the literature that are relevant to this study in both direct and tangential ways. This study is concerned with the impact of delivery methodology on student success, retention, and persistence in remedial mathematics among students in a Kentucky community college; therefore, a significant portion of this review will focus on other studies examining differences in student achievement based on delivery methodology. Also, it is critical to examine studies focusing on characteristics of remedial mathematics and community college students in an effort to develop a full understanding of the cultural factors which may impact student achievement, retention, and persistence.

Understanding the current state of research in each of these topics is an important component of the core of this study, but the overall importance of the study is based on the recent proliferation of online courses in higher education. Because the value of this research is anchored on the increasing number of online courses, this review will begin by examining the research concerning the growing number of online courses, particularly in community colleges.

Growth of Online Courses

Economic changes are driving more students to higher education in general, and, in the years following the recession in 2008, the highest projected growth rates were predicted for community colleges (Ashby et al., 2011; Johnson & Kasarda, 2008). A report in 2015, however, reveals that the increase in community college enrollment nationwide peaked and began to decline as the nation’s economy improved beginning in 2012. This decreased enrollment is most marked among students greater than 24 years old, and some hypothesize that this may be a result of adult students returning to the work force (Juszkiewicz, 2015).

This national trend can also be witnessed in the yearly fall enrollment data for KCTCS. From 1999 to 2015, the system's fall enrollment increased from 52,795 students to 80,075 students; however, closer examination of these data show consistent growth from 52,795 students in 1999 to 89,942 students in 2008. Then, there was dramatic growth from 2008 to a historical high of 108,302 students in 2011. Since 2011, though, the system's fall enrollment has declined back the 80,075 figure in 2015 ("Fall Enrollment," n.d.).

While enrollments peaked and began to decline through the difficult economic times, budgets at community colleges have not increased. Therefore, community colleges have sought creative and efficient avenues to accommodate growing student populations. This need for efficiency which is necessary to serve more students on tighter budgets has been a primary motivating factor in the growing number of online courses offered at community colleges (Ashby et al., 2011; Driscoll et al., 2012; Frantzen, 2014; Lyke & Frank, 2012). While there is a clear economic motivation underlying the increase in online education, there remains academic disagreement on the educational effectiveness of these course delivery methods (Ashby et al., 2011; Fike & Fike, 2008). The effective lure of online courses can be understood from both student and institutional perspectives, but a debate continues on the pedagogical implications of online course offerings (Herman & Banister, 2007).

More than 30% of all higher education students take one or more online courses, but community college students participate in these courses to a higher degree (Driscoll et al., 2012). Community college students now account for 54% of online enrollments (Ashby et al., 2011; Bambara, Harbour, Davies, & Athey, 2009). The attractiveness of asynchronous online courses for community college students is driven by flexibility of time and location (Bambara et al., 2009; Castle & McGuire, 2010; Frantzen, 2014; Summers et al., 2005). This flexibility of time and location is particularly beneficial for students with logistical difficulties such as taking classes around work schedules and childcare obligations (Bambara et al., 2009). The need for access that is being offered through internet-based technologies has become a rationalization for educational administrators willing to do “whatever it takes to … get them educated to a higher level” (Cox, 2005).

While the attractiveness of online courses can be understood from a student perspective, institutional factors are also driving growth in online course offerings. Many articles cite online courses as an opportunity to efficiently utilize existing resources and competition for enrollment-based funding is increasingly a reason for schools to engage in online education (Ashby et al., 2011; Cox, 2005; Driscoll et al., 2012; Frantzen, 2014; Lyke & Frank, 2012). In addition to enrollment-based funding, there is growing political pressure to address the amount of student debt in higher education. In 2014, with national attention focused on levels of student loan debt and the total national student loan debt exceeding $1 trillion, the low marginal cost of enrolling additional students in online courses as well as the potential for larger class sizes was touted as an opportunity to bring down the cost of a class for each student. These benefits are seen by many as a way to positively impact student debt while helping schools meet financial obligations (Nguyen, 2015).

Detailing the attractiveness of online courses for students coupled with the institutional and economic benefits of courses offered in this format provides a positive argument for online education, but it is critical to also recognize that the support for increased online course offerings is not universal. Cox (2005) indicates substantial support for increased online education from college administrators, while at the same time mentioning college faculty who continue to harbor concerns. The rhetoric on online education is two-sided. While proponents cite flexibility and individualization for students through asynchronous online platforms, opponents draw attention to the distance between students and professors as well as a "McDonaldization" of courses eliminating the particular skills and expertise of an instructor (Driscoll et al., 2012). While some of the skepticism has arisen from valid concerns, such as student access to technology and previous online learning experiences, some of the criticism may reveal a generation gap between educational leadership and students (Trenholm, 2006).

Economic advantages should not overwhelm educational considerations. New technologies allow for new modes of communication, but the goals of education are not determined by the delivery methodology (Allen, Mabry, & Mattrey, 2004). Research is needed, especially in light of evolving online learning applications, to ensure that student learning and academic support are not negatively impacted by online learning opportunities (Ashby et al., 2011; Fike & Fike, 2012; Means, Toyama, Murphy, Bakia, & Jones, 2009). Many studies cite Russell's (1999) *The No Significant Difference Phenomenon* in suggesting that delivery methodology has no impact on student achievement, but the actual findings of the underlying studies are more divided than the name suggests (Driscoll et al., 2012).

The No Significant Difference Phenomenon

Since Russell's (1999) work was published, there has been a high degree of interest in the efficacy of distance education as compared to traditional face-to-face instruction. There is even a website, hosted by the Western Interstate Commission for Higher Education, that is intended to serve as a repository for related studies which occurred after or were not included in Russell's book ("The No Significant Difference Phenomenon," 2016). While this early work was encouraging to supporters who touted advantages of online learning for students, the literature proves to be more divided than the book's title suggests. Though meta-analysis of the literature tends to show a lack of significant difference, in reality this is as a result of an essentially evenly divided set of literature between studies finding better student achievement in online versus face-to-face instruction and visa-versa (Driscoll et al., 2012; Means et al., 2009; Nguyen, 2015).

Issues with studies. Beyond the inconsistencies in the literature, researchers are finding a number of other issues with many of the studies purporting no significant difference (Summers et al., 2005). This section will identify a number of these issues as well as recent developments in the field.

Even a cursory search of literature regarding online education will encounter Russell's (1999) seminal work as it is cited over 1900 times, but, despite this, there is still substantial debate because of issues noted in a large number of the studies supporting his finding. The issues researchers have raised with the studies are varied, but commonly there are a variety of methodological concerns as well as less consistency of results than is commonly suggested. One significant issue cited concerning research touting no significant difference in student learning outcomes is selection bias in the participants (Nguyen, 2015). Because of the selection bias of these studies, it is unknown how many of them would come to a different conclusion otherwise, so these studies are of questionable value (Lyke & Frank, 2012; Nguyen, 2015).

There are a variety of other methodological issues which are raised in analyzing online studies showing no significant difference in student learning. Most of the studies are observational on self-selected groups, and the difference in student populations between online courses and face-to-face courses can be non-trivial (Driscoll et al., 2012; Lack, 2013; Lyke & Frank, 2012; Nguyen, 2015). In addition, a substantial portion of studies show a lack of control groups, substantial differences in content and course materials, non-standardized methods of evaluating student success, small sample sizes and a failure to replicate findings (Driscoll et al., 2012; Nguyen, 2015). A recent analysis revealed that most studies were modest in size, and only five studies included more than 400 student participants (Means et al., 2009).

In regards to the current study, there is one additional issue that is particularly relevant. The majority of studies cited by Russell (1999), and in the majority of studies since Russell's publication, are focused on well-prepared students, and these studies do not account for the differences in student aptitude (Frantzen, 2014; Xu & Jaggars, 2011). Little evidence exists for the relative effectiveness of online instruction for low-income and academically underprepared students (Xu & Jaggars, 2011). This finding is particularly critical in relation to the current study which is focused on remedial mathematics students.

While 92% of studies available at nosignificantdifference.org conclude that online learning is at least as effective as traditional instruction, methodological issues make it difficult to judge the meaningfulness of many of these conclusions (Nguyen, 2015). The net effect of the methodological limitations of studies into the efficacy of online instruction results in the limited value of these studies for determining the amount of investment that school's should make into these courses (Lack, 2013). As a result, studies into the effectiveness of and student satisfaction in online courses should remain a research priority (Lyke & Frank, 2012).

Recent developments. More recent studies into the efficacy of online instruction continue to suggest that online education can be at least as effective as traditional alternatives, but any real difference is modest (Driscoll et al., 2012; Means et al., 2009). There have been a number of developments, though, bringing to light best practices both in general and for specific subpopulations, such as mathematics courses for community college students, that will also be considered in this section.

Nguyen (2015), through careful analysis of a variety of studies, concludes that the current state of research into the efficacy of online education reveals that student achievement is modestly better in online courses, though the effect size of this difference is greatest in courses that blend online and face-to-face components. Finding similar results, Means et al. (2009) also concluded that online courses had greater effect sizes than face-to-face instruction when the online instruction is facilitated by an engaged instructor rather than the instruction being completely asynchronous. Because of conclusions such as these, it is time for researchers to move beyond simple adherence to the No Significant Difference mantra and reconsider arguments for online learning which are not built upon that phenomenon alone (Nguyen, 2015).

Lack's (2013) meta-analysis of current research into online education at the postsecondary level did not conclude, as the literature cited in the previous paragraph, that online learning produced better student outcomes; however, this work concluded that there was little if any evidence to show that online learning was less effective than face-to-face instruction. Though this is an argument by contradiction, a lack of evidence suggesting that online education is less effective than traditional delivery methods is an argument against opponents of online educational offerings.

Studies into the relative effectiveness of online instruction continue to show either no statistical difference in student learning outcomes or advantages toward the utilization of online learning platforms, but these studies are narrowly focused. Studies revealing such favorable conclusions exist for online learning in environments ranging geographically across the nation and educationally from community college to graduate school; however, these studies are already factored into meta-analysis work revealing only little to any difference in student achievement (Bendickson, 2004; Herman & Banister, 2007; Lyke & Frank, 2012). Therefore, attention should be directed toward studying the relative effectiveness of online education in particular contexts and in looking for patterns of successful online instruction (Dupin-Bryant, 2004; Nguyen, 2015).

Ashby et al. (2011) conducted an analysis on the impact of delivery methodology, comparing online, blended, and face-to-face methods, in developmental mathematics courses at a community college, and the initial results contradicted other evidence. They found that students receiving face-to-face instruction achieved at higher levels than online students. This study measured student success both by the percentage of passing grades and by the student's scores on a standardized final exam. However, these results reversed, with online students out-performing face-to-face students, when the authors trimmed the sample to only include students who finished the entire course since the attrition rate was significantly higher among the students in online courses in this study (Ashby et al., 2011).

This pattern of online students having a high success rate when compared to students in face-to-face sections of a course is not consistent, and there is even evidence that lower performing students performed better in the face-to-face sections (Peterson & Bond, 2004). However, most of these studies were focused only on well-prepared students, yet the population of remedial mathematics students in a community college is considerably different (Xu & Jaggars, 2011). These differences, though, suggest that questions of retention and persistence are important to consider particularly among community college and underprepared students, thus these topics will be considered at length later in this chapter.

Impact on achievement and satisfaction of online mathematics courses. For the purposes of this study, it is important to consider the state of research concerning the relative effectiveness of online versus face-to-face instruction in developmental mathematics courses.

The research is strongly divided on this point as well. One study at Virginia Tech reported that students in its technical developmental mathematics program, which was taught using online instruction, scored a half letter grade better than other students, but this study was contradicted by the study of a similar course at community colleges in Florida (Bendickson, 2004; Cafarella, 2014; Holton, Muller, Oikkonen, Valenzuela, & Zizhao, 2009). Trenholm (2006) found that community college students in a computer-mediated mathematics course using the software MyMathLab had higher grades on a proctored final example than did students in courses with other delivery methodology; however, these results differ from Ashby et al. (2011) who only found such an advantage using a trimmed sample which controlled for course completion. The literature is divided about the impact of online delivery on student achievement.

Whereas direct student achievement is an important consideration, it is critical, when considering retention and persistence, to also consider the impact on student satisfaction for taking a mathematics course online. One study, which considered the impact on both achievement and satisfaction of using an online delivery methodology in an introductory statistics class, found there was not a difference in student achievement, but student satisfaction with the course was found to be significantly lower as compared to students who took the course in a face-to-face format (Summers et al., 2005).

Factors for success in online education. There are a variety of factors which have been shown to be integral for student success in online education, and a number of these factors are related to the quality of the instructor. Student success is greater if the instructor is able to provide quality explanations and develop clearly defined routines of study for students without direct contact (Herman & Banister, 2007; Summers et al., 2005). In addition, effective online instructors are excellent communicators who are able to demonstrate concern for the student and an interest in student learning in spite of the inherent communication weakness which accompany asynchronous communication mediums as well as geographic distance (Summers et al., 2005). The asynchronous nature of communication does not provide students with normal feedback clues, so it is critical for online instructors to provide timely feedback to student in order to guard against a student developing insecurities within the course (Herman & Banister, 2007).

One of the challenges to online education is the lack of opportunities for contact both between students and between the instructor and students. The designers of a course can help to combat this by intentionally designing instruction around small groups of students. This can help to build community, and it fosters natural avenues for student-to-student assistance (Herman & Banister, 2007). In addition, it is important for instructors to remain positive about a course because instructor perceptions of online education impact student perceptions. This is particularly critical because many instructors still perceive distance learning negatively as a result of the lack of student contact (Allen et al., 2004). While the lack of direct contact is a detriment for some things, there are also advantages. Research has shown that online courses are superior to face-to-face courses in asynchronously designed learning activities (Nguyen, 2015).

Additionally, research indicates that schools can improve the effectiveness of online learning by providing careful advice to students. The nature of online learning requires a degree of self-regulation, so schools should advise only students with greater degrees of self-regulation, which may require new placement tests to effectively measure, to take online courses (Trenholm, 2009). In addition, the majority of studies about the relative effectiveness of online education are focused on well-prepared, motived students and not on the academically underprepared students typically found in community colleges (Xu & Jaggars, 2011). In their study, Xu et al.

(2011) found that students with poorer preparation and lower motivation are more likely to struggle in online courses, and this is an important consideration for community college leaders.

Summation of findings for the No Significant Difference Phenomenon. In two significant meta-analyses of the current state of research into online learning, it was found that there was either no significant evidence of a difference in the relative effectiveness of online learning or that there was a modest advantage in favor of online learning (Lack, 2013; Means et al., 2009; Nguyen, 2015). While these findings lack the evidence to conclusively state that student learning outcomes are superior in online learning, they do provide strong evidence that, in general, online learning is at least as effective as face-to-face instruction in demonstrated student learning outcomes (Means et al., 2009; Nguyen, 2015).

This evidence, though, is considering only the delivery method and not any particular course, discipline, or demographic information. Substantial questions persist about the impact of online learning on students in developmental courses (Zavarella & Ignash, 2009). In a large study of nearly 20,000 community college students, online courses had a significantly negative impact on retention and course grade. Furthermore, when considering differences within a single class, students with lower academic preparation and motivation were more likely to struggle online (Xu & Jaggars, 2011). The preponderance of the evidence suggests that it is prudent for educational leaders to assume a positive but cautious approach to online learning (Lack, 2013). “Well-designed online instruction has great promise. That being said there is an undeniable need for rigorous efforts to assess readily measurable outcomes such as completing rates and time-to-degree, paying attention to differences among different student populations and subgroups” (Lack, 2013).

Remedial Mathematics

Similar to the enhanced importance of mathematics education during the space race which led to an increased number of degrees awarded in mathematics, a new increase in the number of mathematics degrees since 2001 reveals the importance of mathematical mindsets in a global economy (Holton et al., 2009). The growth in mathematics education in degrees awarded, though, is also visible on the other end of the postsecondary education spectrum: developmental mathematics. Changes in the job market has resulted in increasing numbers of older and underprepared students returning to school to acquire necessary training in mathematical and technical skills (Holton et al., 2009; Stuart, 2009).

Developmental education courses serve an important societal function, as it is estimated that two million students would drop out of college without them. Schools, though, have traditionally been slow to embrace developmental education because the presence of such courses lowers the school's academic profile (Stuart, 2009; Wolfle, 2012). Such a second-class status for developmental mathematics has resulted in skill and practice based courses concluded by summative tests philosophically designed for deficit reduction (Bendickson, 2004). Even as economic changes have increasingly demanded that workers seek mathematical training, economic changes in higher education institutions have increased the importance of developmental education on campus. Funding opportunities, such as provided by the Obama administration's $12 billion provision to community colleges to increase graduation rates, and open enrollment policies have resulted in an expansion of remedial education opportunities in community colleges (Ashby et al., 2011; Wolfle, 2012). The current size of developmental mathematics programs at community colleges, coupled with a developing knowledge based economy, suggest that the need for developmental mathematics education will remain strong for the foreseeable future (Trenholm, 2006). The relative scarcity of research into online developmental mathematics, combined with a strong demand for the courses, suggests that continued research into online developmental mathematics should be a research priority (Ashby et al., 2011).

Characteristics of developmental mathematics students. There are a variety of reasons, including poor study habits, mathematical anxiety, a lack of educational support from teachers and others, number of years removed from a formal mathematics classroom, and under-exposure to content, which contribute to a student's need for developmental mathematics (Cafarella, 2014; Fike & Fike, 2012). The level of preparedness for postsecondary mathematics is decreasing, in part due to the open enrollment policies at community colleges admitting students who were not well-prepared in previous educational experiences, to the point that many students are calculator dependent and lack even the most vital computational skills (Cafarella, 2014; Zientek, Schneider, & Onwuegbuzie, 2014). Remediation needs have increased to the point that 56% of first-time-in-college students were recommended for developmental mathematics in a report on Virginia's community colleges (Wolfle, 2012).

For developmental mathematics students, there are a variety of barriers, such as cost, domestic responsibilities, and employment responsibilities, which contribute to student difficulties in developmental mathematics course. In addition to these barriers, the structure of student placement systems should also be considered. Over 90% of colleges utilize some sort of placement system, but the vast majority of placement systems are focused only on subject-specific content. Though some studies suggest that dispositional variables, such as time management, motivation, or personality, have more predictive power than content specific placement exams, only a very small percentage of schools give placement exams testing for these factors (Zientek et al., 2014).

Issues to consider in remedial mathematics. In the relevant literature, there are a variety of issues for educational leaders to consider with regards to remedial mathematics and remedial mathematics students. Student preparation in both content and attitude towards mathematics is a significant issue, and poor preparedness is particularly challenging for online remedial mathematics students (Ashby et al., 2011; Summers et al., 2005). There is recognition that mathematics faculty should embrace technology as an opportunity to rethink the mathematics curriculum in order to harness opportunities afforded by inexpensive computing power (Holton et al., 2009), but the educational preparation of the students for online mathematics courses is also paramount.

In order to be successful in online courses, including online mathematics courses, students need to be self-regulated learners; however, many remedial mathematics students are not self-regulated learners and do not have the necessary educational background to succeed in an online learning environment (Ashby et al., 2011; Driscoll et al., 2012). Rather than approaching online learning with an appropriate expectation of the increased self-regulatory responsibilities imposed on the student, students often report believing that online courses will be considerably easier than courses delivered in a more traditional manner (Bambara et al., 2009).

In his study of best practices in remedial mathematics, Cafarella (2014) found that two of the significant reasons for a lack of student success in developmental mathematics were student attendance and work habits. This is consistent with other studies which found that faculty often report student immaturity and poor study skills as substantial contributing factors in the lack of student success for developmental mathematics students (Zientek et al., 2014). Students in developmental mathematics courses are hampered in their efforts to understand more complex mathematical concepts by a poor foundation in arithmetic, but these students are also most likely to attempt to learn mathematics by memorizing abstract formulas and procedures rather than developing an understanding of the material by drawing deep connections between concepts (Cafarella, 2014).

There are also unique communication challenges for online mathematics courses which inherently increase the difficulties for developmental students (Ashby et al., 2011). Online education is not as conducive to passive learning styles as face-to-face instruction is, and students in developmental mathematics courses are often passive mathematics learners (Ashby et al., 2011; Driscoll et al., 2012). Beyond learning styles, it is difficult for online mathematics students to ask technical or procedural questions because of the unique set of mathematical symbols that are often necessary (Driscoll et al., 2012).

Student attitude toward mathematics is also a predictor of success in mathematics courses (Summers et al., 2005), and this has implication for developmental mathematics students. A lack of past success can negatively impact a student's attitude toward mathematics, and this is critical in considering remedial mathematics students because such students have, by definition, demonstrated a lack of success in the discipline (Summers et al., 2005). One practice which can help to combat such a psychological barrier is the use of frequent formative assessments with few high stakes exams so that the instructor can work to manage the student's attitude and outlook (Cafarella, 2014).

The diverse nature of remedial mathematics courses also creates instructional challenges. Students with relatively high skill sets can become bored while those with particularly poor preparation can fail to keep up with the pace of the course (Trenholm, 2006). Certainly students with the greatest needs have difficulty passing developmental mathematics courses, but it has been shown that there is a negative correlation between student confidence and final exam scores among remedial mathematics students (Guy, Cornick, & Beckford, 2015). The boredom experienced by students who have relatively high skills sets among developmental mathematics students may result in a lack of attention to the course material and subsequent grade struggles (Guy et al., 2015; Trenholm, 2006). Online learning platforms, though, can provide one avenue to address such differentiation challenges (Trenholm, 2006). In addition, the connection between first semester success and educational attainment among adult students suggests a heightened importance on placing students into a course that maximizes the likelihood of student success (Frantzen, 2014).

While developmental mathematics courses are designed to help students reach educational goals, these courses, which contain a disproportionately high rate of minority and first generation college students, are the most difficult for students to pass in all of higher education (Bonham & Boylan, 2012). Students who are able to be successful in remedial mathematics courses perform on par in college level mathematics as students who did not need remediation prior to taking a college level math class; however, the rate of ultimate success decreases as students need more than one developmental mathematics course (Fike & Fike, 2012). Students who place into the lowest mathematics courses nationwide must, on average, complete 10 hours of coursework before being eligible for a college-level course, and these students are unlikely to earn transferable credit (Bonham & Boylan, 2012). In a report of remedial students in California, it was found that only 14% of students beginning in the lowest math course offered were able to earn credit that was eligible for transfer to the University of California or California State University systems within eight years of initial enrollment (Rosin, 2012).

The poor student success rate in developmental mathematics courses is a national crisis that is beginning to attract political attention (Cafarella, 2014). One initiative, which has evidence to support it, aimed at increasing the student success rate in these courses is to adopt a compressed approach to developmental mathematics. This approach reduces the number of levels of remedial courses offered, which can increase student success and decrease fatigue with the process (Cafarella, 2014). Such modifications to the developmental mathematics offerings are at least being considered in community colleges in Kentucky (T. Ragsdale, personal communication, 2016).

Remedial mathematics instruction is often taught as a repeated high school mathematics course without a greater plan to improve the student’s mathematical mindset as much as mathematical skills. In developmental mathematics classes, the growth of thinking skills is as important as the computational skills (Stuart, 2009). To address the unique strengths and weakness of particular students, as well as to emphasize applied mathematical thinking, some schools are teaching remedial mathematics as individual units which are, sometimes, embedded in other courses (Rosin, 2012; Stuart, 2009; J. M. Wenner et al., 2011).

A final substantial issue for educational leaders to consider in regards to online developmental mathematics instruction is the importance of developing relationships between students and faculty. Previous struggles in mathematics can result in mathematical anxiety or a lack of mathematical self-efficacy (Summers et al., 2005). Because of this generally lower mathematical self-efficacy, it is critical for developmental mathematics students to receive clear directions, timely feedback, and personal encouragement from instructors in order to reduce a student’s anxiety in the course (Herman & Banister, 2007; Summers et al., 2005). Even among otherwise engaged students, mathematical motivation appears to be a separate attribute than academic motivation, so instructors should be particularly diligent in communicating with and encouraging remedial mathematics students (Guy et al., 2015).

Mathematical self-efficacy. One of the persistent challenges of developmental mathematics education, regardless of delivery methodology, is the low mathematical self-efficacy of a substantial portion of students (Malpass, O'Neil, & Hocevar, 1999; Zeldin et al., 2008). Self-efficacy describes one's belief in an ability to complete a task or objective, and self-efficacy theory clearly connects a student's engagement in and motivation to complete a task with the student's level of self-efficacy for that task (Simzar et al., 2015; Zeldin et al., 2008).

Economic realities have increased the national awareness for and emphasis on the need for more and more diverse STEM professionals in the United States (Hossain & Robinson, 2012). In order to increase the diversity of STEM professionals, however, educators will need to maximize the implicit intellectual capital of students, which has not been fully realized among under-reached minority and non-traditional students (Gautreau, Kirtman, & Guillaume, 2011; Hossain & Robinson, 2012; Zeldin & Pajares, 2000). Research, however, reveals that these same groups, including minority students and women, have relatively lower mathematical self-efficacy on average than white males even when controlling for past achievement levels (Gautreau et al., 2011; Malpass et al., 1999; Schweinle & Mims, 2009; Zeldin et al., 2008).

Mathematical anxiety is well-documented as a deterrent to student achievement, and students with lower past academic performance, such as students in developmental courses, tend to have greater levels of anxiety (Zientek et al., 2014). As self-efficacy is positively related to achievement and negatively related to worry, remedial mathematics education should focus not only on the development of mathematical skills, but it should also focus on increasing student attitudes and self-confidence in mathematics while decreasing mathematical anxiety (Benken, Ramirez, Xuhui Li, & Wetendorf, 2015; Bonham & Boylan, 2012; Malpass et al., 1999; Usher & Pajares, 2006a). If educators are able to successfully build mathematical self-efficacy among remedial mathematics students, research suggests that student resilience in mathematics will increase (Simzar et al., 2015).

Developmental mathematics students often have a high degree of anxiety for the discipline based on previous exposure and the erroneous belief that mathematical ability is a fixed metric (Boaler, 2016). Many students are taught to believe, even from a young age, that they are incapable of being successful in mathematics, and this teaching has negative long-term impacts (Boaler, 2016; Rosin, 2012). If a student is able to have early success in mathematics, then it is possible to ride that initial inertia toward overall educational success; however, a lack of initial success can discourage students from putting forth the necessary efforts to complete their studies (Rosin, 2012).

Evidence of a connection between mathematical self-efficacy and academic success has been found across a broad range of ages and ability levels, from elementary school children to adult college students (Jameson & Fusco, 2014; Simzar et al., 2015). Even among high achieving secondary students taking Advanced Placement Calculus, self-efficacy is a better predictor of success on the standardized exam than classroom performance, and this is mainly because a healthy self-efficacy builds motivation and an increase in efforts which contribute to student achievement (Malpass et al., 1999; Ryan, Ryan, Arbuthnot, & Samuels, 2007; Simzar et al., 2015).

Self-efficacy is developed through the interaction between four primary components: mastery experiences, vicarious experiences, social persuasions, and physical and emotional states (Usher & Pajares, 2006b; Zeldin et al., 2008; Zeldin & Pajares, 2000). The perception of past mastery experiences has been shown to be the strongest determinant of mathematical self-efficacy, and developmental mathematics students often bring a sense of struggle and past failure to the current learning experience (Usher & Pajares, 2006b; Zeldin & Pajares, 2000). This, though, is an inherent difficulty in remedial mathematics education, and there is little that community college leaders can do to impact a student's past mastery experiences. However, self-efficacy is also influenced by vicarious experiences and social persuasions. The educational climate and culture around the student impacts the student's belief in his or her ability to be successful in mathematics (Usher & Pajares, 2006b; Zeldin et al., 2008; Zeldin & Pajares, 2000).

Cultural factors can be addressed by educators in order to encourage self-efficacy in the classroom. Research indicates that classrooms which deemphasize competition and social comparisons are effective in building self-efficacy (Malpass et al., 1999). Appropriate placement of students in courses which allow for student success can be helpful for the development of self-efficacy. Finally, verbal encouragement, praise, and celebrations of past student successes helps to impact self-efficacy through the vicarious experiences and social persuasions channels (Fall & McLeod, 2001). Interventions for remedial mathematics students need to be specifically aimed at developing mathematical self-efficacy in addition to remediation on particularly mathematical skills (Wood, Newman, & Harris III, 2015).

Community Colleges

When considering the impact of delivery methodology on student success, retention, and persistence for remedial mathematics students at a community college, it is important to consider the unique characteristics of community college students. The majority of community college students attend school part time while also working at least 20 hours each week, and many community college students, nearly a third, are engaged in caring for dependents at least 11 hours each week. These data, coupled with the fact that the majority of community college instructors teach on a part-time basis, are a primary reason for the small amount of interaction between faculty and students outside of the classroom at community colleges (Powers, 2007).

One of the major challenges for educational leaders in community college settings is the high student attrition rate (Ashby et al., 2011). Community colleges have traditionally been too passive in building connections with students often only publishing information while not making efforts to ensure that students receive it. The efforts required to engage students on community college campuses are more challenging than at traditional, residential colleges because there is a lack of on campus activities through which organic interactions can occur. These efforts are needed and apparently desired as 90% of community college students state the importance of advising and student services (Powers, 2007). Community college student characteristics and student preparation will be considered independently in an effort to understand the environmental challenges associated with community college leadership, particularly leadership within developmental mathematics.

Student characteristics. Across all institutions, the adult student population, defined as those over 25 years of age, is increasing at a greater rate than traditional student enrollment. More than one-third of students nationally are adult students, and this is expected to increase substantially by 2018 (Frantzen, 2014). The percentage of adult students is even greater among community college students, with some authors reporting an adult student population of up to 60% (Fike & Fike, 2008). Frantzen (2014) reports that there are no known studies examining the effect of using technology in instruction and its impact on academic performance for nontraditional students. Instructors and administrators should be aware of, and take into account, differences, such as learning styles, between adult and traditional college students (Frantzen, 2014).

Adult learners in community colleges are often returning to school following a considerable amount of work experience, and many of these students continue to work, some full-time, while in school (Cafarella, 2014; Frantzen, 2014). Because of relatively low tuitions and open enrollments, community college students are more likely to be minorities and have lower economic means than students in other colleges (Fike & Fike, 2008; Frantzen, 2014). In addition, community college students are much more likely to be first-generation college students (Fike & Fike, 2008). These students are overcoming numerous challenges, both vocational and personal, and they are motivated to attend college by a diverse set of reasons including hopes of gaining a transferable degree, earning a terminal certificate, development of vocational skills, or merely for personal development (Fike & Fike, 2008; Frantzen, 2014).

The challenges faced by adult students often lead these students to enroll in online courses. Students participating in online courses are more likely to be non-traditional (Xu & Jaggars, 2011), and this serves a good educational function. Adult students enrolled in online courses are less likely than those enrolled only in courses that utilized face-to-face instruction to have an enrollment gap because the asynchronous nature of many online courses allows students to fulfill other obligations (Driscoll et al., 2012; Frantzen, 2014). Though the lack on an enrollment gap is a positive, students in online courses tend to have lower grades, take fewer hours each semester, and work part-time and full-time jobs more than students only enrolled in face-to-face classes (Driscoll et al., 2012).

Online courses can allow students to work at individualized times and speeds, including additional time for review of materials; however, there are also disadvantages to online instruction (Driscoll et al., 2012). Adult students, because of other obligations, often have difficulties becoming proficient in using online learning platforms, and this can result in anxieties. Frontloading courses with materials designed to teach students how to use the particular platform driving the course can help to relieve these anxieties promoting successful completion of the courses (Frantzen, 2014).

Preparation of students. Students electing to participate in online courses, regardless of type, require a degree of preparation, both in skills and attitudes, in order to be successful. Research indicates that successful online learners must be comfortable in a learner-centered environment and assume a greater degree of personal responsibility for their learning (Driscoll et al., 2012; Summers et al., 2005). However, students in developmental courses often have low self-efficacy in regard to academic tasks, so it is important that schools and instructors provide a greater level of communication and pre-course training to prepare developmental students for success in an online environment (Zavarella & Ignash, 2009). In a study of online developmental writing courses, it was found that students could be most successful if the course required an orientation, made expectations clear, and required students to initiate an activity, such as a quiz or required email, early in the course (Carpenter, Brown, & Hickman, 2004). In a study of a successful online graduate level course, which is at the other end of the higher education spectrum, it was found that making substantial efforts to train students on how to utilize the course's learning management system was an important component of creating a successful learning experience for students (Herman & Banister, 2007).

Beyond training in course specific skills, communication is a critical element necessary to develop a successful online course. There are different communication skills necessary for students and instructors in online courses, but quality courses have been shown to have a variety of types of communication, often initiated by the student, between students and the instructor (Allen et al., 2004; Driscoll et al., 2012). One of the inherent challenges for online learning is the inability of an instructor to provide immediate feedback to a student. For self-regulated students with healthy self-efficacy, this delayed feedback may actually enhance the educational experience because it allows time for students to discover answers on their own, but this feedback delay can be paralyzing for students who are already struggling with confidence in their abilities (Boaler, 2016; Driscoll et al., 2012).

The communication challenges presented in all online courses are amplified when focusing only on developmental mathematics students. Remedial mathematics students are often unaware of their own learning needs, and these students regularly select surface-level learning strategies because the course is believed to be merely a requirement which is not actually useful or meaningful (Summers et al., 2005; Zavarella & Ignash, 2009). The consequences of an ignorance about individual learning needs and surface-level learning strategies are often a lack of student success and regret. When interviewed after failing to complete online mathematics courses, students reported that the courses were much more challenging than expected while also expressing that it was a mistake to attempt to learn mathematics through an online course (Zavarella & Ignash, 2009).

Community colleges struggle to place and prepare students for success because of a relative lack of student information compared to more selective schools. Open admission policies result in students being placed into classes by tests such as the Compass, but these tests are “insufficient in terms of providing enough information to determine the appropriate course of action that will lead to academic success for a vast range of underprepared students” (Guy et al., 2015). Up to 25% of student success can be attributed to non-cognitive measures such as attitude, motivation, and a desire to seek assistance in learning, but these factors are not measured by traditional placement tests. Some researchers have recommended that schools place students based on affective and developmental characteristics, in addition to cognitive measurements. Affective characteristics can be measured, in general, by ACT's Engage assessment and, specific to mathematics, by the Attitudes Towards Mathematics Inventory (ATMI) (Guy et al., 2015).

Retention

As educational leaders make decisions concerning remedial mathematics program offerings, student achievement is only one consideration. Student retention rates are also an important decision factor, and evidence suggests that community college, first-year students, and online education students have relatively low retention rates (Ashby et al., 2011; Dupin-Bryant, 2004; Wolfle, 2012). The difference in retention rates between community college students and four-year university students implies that studies of university students should not be used by leaders as they are considering best practices for community college students (Ashby et al., 2011). Lower retention rates among community college students have been attributed to risk factors, such as lower high schools grades, prior educational deficiencies, skills, and ethnicity (Ashby et al., 2011; Dupin-Bryant, 2004).

Retention rates have always been important to educational leaders for a variety of reasons, such as the financial stability of the institution, the ability to sustain academic program, and student experience; however, schools are often more focused on recruitment of new students than they are in fully serving and retaining those who are currently enrolled (Fike & Fike, 2008). Decisions made by external agencies have amplified the importance of retention rates in recent years. The federal Higher Education Act allows the government to measure institutional effectiveness by graduation rates, so public policy makers are beginning to use retention rates in accountability schemes (Cafarella, 2014; Fike & Fike, 2008). Attrition has a negative impact on the ability of students to achieve educational and economic goals, and it also has ramifications for the economic future of society. However, the goal of retention efforts must remain educationally focused. Merely increasing graduation rates at the expense of the quality of the education provided is counter-productive (Fike & Fike, 2008). There is evidence, though, that schools are beginning to actively work on reinventing developmental mathematics programs with increasing retention as a goal of these efforts (Bonham & Boylan, 2012).

The three major models of retention in higher education are Tinto's student integration model, Bean's student attrition model, and Astin's Input-Environment-Output model. Tinto's model understands retention as being related to the level of student integration into the university community beginning with the student's first college experience. Bean attempts to predict student retention based on background variables, and Astin's model understands retention as a combination of student background and environmental factors (Fike & Fike, 2008). Though each of these models use a variety of factors to predict student retention, each model is based on research of traditional university students, so the findings should not be directly applied to non-traditional or community college students (Ashby et al., 2011; Fike & Fike, 2008).

Fike and Fike (2008) showed that developmental mathematics courses can result in a significant increase in retention rates for community college students. Students who have succeeded in a developmental mathematics course had greater odds of retention than those who enrolled but did not pass a developmental mathematics course; however, even community college students who enrolled in but did not pass a developmental mathematics course had higher retention rates than similar students who did not enroll in a developmental mathematics course at all (Fike & Fike, 2008). The underlying reason that enrolling in and not passing an online course results in greater rates of retention when compared with students who did not enroll in a developmental mathematics course at all is unknown at this time, but Fike and Fike (2008) believe that this merits additional study.

One of the key reasons that enrolling in developmental mathematics courses may increase retention is because these classes, when offered using face-to-face instruction, often have small class sizes and emphasize student integration to college (Wolfle, 2012). This positive impact, though, is limited. Studies show that the impact on retention resulting in students successfully completing remedial courses becomes a negative relationship when students take at least three such courses (Goeller, 2013).

Students enroll in developmental mathematics courses in order to fulfill educational or vocational goals, but these courses have a high risk of failure for many students. When these courses are offered online, students often perceive the course as an educational hurdle to clear rather than the course being an enjoyable and intellectually stimulating experience which contributes to greater educational goals. Students who eventually drop out of such courses report a sense of loss as they begin to lose hope, watching an opportunity to achieve educational goals and dreams slip away (Bambara et al., 2009). Rather than understanding these courses as opportunities to weed out underqualified students, it is becoming more common for schools to think of these courses as opportunities to help students succeed both in the class and in achieving larger educational goals (Stuart, 2009). Schools have traditionally collected a variety of demographic data, but they have not fully utilized these data to effectively place students into courses with the greatest opportunity for immediate success (Fike & Fike, 2008; Goeller, 2013). One of the ways to truly help students succeed in the short-term and in achieving educational goals is to work on appropriate initial course placement. This is recommended because there is a strong correlation between earning good grades in the first semester of higher education and eventual degree completion (Frantzen, 2014).

Much of the above discussion was centered on face-to-face developmental education, but there are some unique findings in the literature for online developmental courses and student retention. Though retention rates are generally lower for online students, and this is usually understood to be a product of different relationships between students and faculty in an online environment, research indicates a significant improvement in retention for non-traditional students enrolled in online courses (Ashby et al., 2011; Fike & Fike, 2008; Frantzen, 2014). This seeming contradiction, though, may be explained by the added flexibility that online courses afford non-traditional students who may not be able to fully participate in face-to-face courses offered at traditional class times (Fike & Fike, 2008).

Persistence

A substantial concern among educational leaders concerning all students is the rate of persistence to degree or program completion, and this concern is amplified for students needing to take remedial mathematics courses (Wolfle, 2012). Even students who pass every developmental mathematics course they enroll in are not certain to persist through the developmental program and into a college-level mathematics course. Some studies show that up to 70% of students who ultimately fail to complete a prescribed developmental sequence passed all of the individual developmental courses that they attempted (Bailey, Jeong, & Cho, 2010). Students with the greatest financial needs, students who are enrolled part-time, and students with a substantial time delay before beginning college are less likely to persist to graduation (Wolfle, 2012; Zientek et al., 2014).

Nearly half of all community college students drop out before obtaining a degree or credential, but this rate is even higher for students beginning school in developmental courses (Wolfle, 2012). Higher education, as a whole, is investing $5 billion annually for developmental education programs, but a substantial number, at least 75% and possibly more than 81.5%, of students who attempted at least one developmental mathematics course did not ultimately complete a degree or transfer to another school (Cafarella, 2014; Wolfle, 2012). If one judges the successful completion of a college-level mathematics class to be the standard of persistence for remedial mathematics students, as opposed to earning a degree or transferring to another school, still only 20% of students referred to a developmental mathematics course will complete a college-level mathematics course within three years (Bailey et al., 2010).

Remediation can be effective, and initial success in remedial mathematics can serve as a springboard to overall college success, but a large percentage of students, up to 70% in a study of community college students in Virginia, never even reach a college-level mathematics course (Benken et al., 2015; Wolfle, 2012). If a student, however, succeeds in developmental mathematics courses, then, and this is a testament to the potential effectiveness of developmental mathematics courses, the success rate in college-level mathematics is similar to students who did not require remediation (Wolfle, 2012). On the other hand, a lack of student success in remedial mathematics can be discouraging, leading to a decline in confidence, attitude, self-efficacy, and an increase in anxiety, and this discouragement can lead to an increase in student drop-out rates (Benken et al., 2015).

Schools have traditionally under-valued developmental courses, but the argument is now being made that schools should make these courses an institutional priority precisely because successful completion of developmental courses is a strong predictor of student persistence (Fike

& Fike, 2008). There is evidence that schools are changing the understanding of developmental education, and it is being valued to greater degrees in recent years. As George Boggs, past president of the American Association of Community Colleges said:

> Colleges never saw remedial education as their mission. They felt that their job was giving an opportunity. If the student succeeded, great! Higher education has never been rewarded for the success of its students, only enrollments. A few years ago, starting with community colleges, we decided to change this paradigm (Stuart, 2009).

Course Completion

Beyond retention and persistence, a third area of potential concern in developmental education is whether or not there is a difference in the rate of completion of an individual course between online and face-to-face course designs. There is well-documented evidence to suggest that students in online courses, particularly computer mediated courses, are more likely to either withdraw from or just not complete the online course than they are to complete the same course taught in a face-to-face format (Ashby et al., 2011; Carpenter et al., 2004; Zavarella & Ignash, 2009). Some authors are less convinced of the voracity of the evidence, but even these authors state that the evidence which does exist suggests that online remedial education student are more likely to withdraw than students in face-to-face courses (Xu & Jaggars, 2011). Some differences in course completion rate, though, may be a result of demographic differences among students. In a follow-up study concerned with why students withdrew from an online course, admittedly with a small sample size, students claimed “job, family, or medical reasons” for dropping the course (Zavarella & Ignash, 2009).

The course completion variable adds a new dimension to the research on the relative effectiveness of online versus traditional delivery methodologies in developmental mathematics because most of the current studies are only considering the grades of students who persisted until the end of the course (Xu & Jaggars, 2011). In one study, online students had lower achievement overall, but the result reversed and online students outperformed face-to-face students when the researchers limited the study to only those students who completed the course (Ashby et al., 2011).

Dupin-Bryant (2004), in light of this, suggests that identifying variables which distinguish between students who are more or less likely to complete online courses would be helpful for educational leaders working to develop procedures to serve at-risk students. First and second year college students, students with lower grades, and students having taken fewer computer training courses are currently known to be less likely to complete online courses, and this lends some credibility to authors who claim that frontloading online courses with information about how to be successful in the course is a best practice (Driscoll et al., 2012; Dupin-Bryant, 2004). Students often enroll in online courses believing that such courses will be easier than lecture-based approaches, and these students often drop-out when they realize that online learning requires an even greater degree of student responsibility (Bambara et al., 2009; Zavarella & Ignash, 2009). One study, which supports the argument on student responsibility, found that students in online developmental mathematics courses complain of a lack of tutoring services, but faculty report that these same students fail to participate in tutoring opportunities even when the students are already on-campus for other reasons (Zavarella & Ignash, 2009).

Conclusion to Literature Review

There is a growing need, based on a rapidly globalizing and technical economy, to provide higher educational opportunities for adults and under-prepared students, and remedial mathematics courses are a critically important step in the transition to college. Sections of developmental mathematics that are offered online can provide greater access, but it opens questions concerning the relative effectiveness of these courses as compared to courses delivered using face-to-face methods.

In reviewing the literature relating to the relative effectiveness of course delivery methodology on remedial mathematics courses, it was found that there is a great deal of related research, but little known information focused specifically on developmental mathematics in community colleges. There is a general acceptance that there is not a significant difference in student achievement between online and face-to-face delivery methods, but much of this work is centered upon undergraduate or graduate students at four-year universities. There is significantly less evidence from research that is focused specifically upon community college mathematics students.

Characteristics of developmental mathematics students in community colleges, particularly issues of motivation, self-efficacy, work ethic, and the ability to self-regulate learning, differentiate this population from many of those previously studied who generally represent well-prepared students enrolled in traditional, four-year colleges. The continued increase in online educational offerings to these students coupled with the lack of direct research on the topic suggests that additional research on the topic is important.

Additionally, there is concern raised in the literature that among students enrolled in online developmental mathematics courses, the advantages provided by online delivery systems in terms of individualization and flexibility have a detrimental effect on the course completion rate, retention, and persistence as previously defined. The available literature suggests that each of these rates is negatively impacted for courses delivered through online strategies; however, the literature also shows that these courses provide educational opportunities for non-traditional students who could not participate in face-to-face courses.

Chapter 3

Methodology

This chapter addresses the methodology that was used to answer the seven identified research questions stated in Chapter 1. This includes selection of subjects, data collection, and the type and validity of the quantitative analysis implemented. In order to keep sight on the greater objective, it is important to recall that each of these questions provided important insight into the over-riding question of this study: *How does student achievement, retention, and persistence compare in remedial mathematics courses between online and traditional delivery methods?*

Selection of Subjects

This study sought to address the seven research questions through a quantitative analysis of historical data. One of the weaknesses of non-experimentally designed studies is the difficulty of controlling for confounding variables (Driscoll et al., 2012). As such, this study controlled for as many variables as possible. The primary effort to control for extraneous variables was to only use data from one community college in the Kentucky Community and Technical College System (KCTCS). This helped to control for curriculum, instructor, and cultural variables leaving the course delivery methodology as the primary variable remaining which accounted for any statistically significant differences observed in the data. This approach was modelled after and adapted from the Ashby et al. (2011) study of student success in developmental mathematics courses.

The subjects for this study were all Somerset Community College (SCC) students who had enrolled in at least one remedial mathematics course (MAT 055, MAT 065, or MAT 085) between the Fall 2011 and Spring 2016 semesters. This was a substantial sample containing

6,467 student enrollments in MAT 055, 7,277 student enrollments in MAT 065, and 2,922 student enrollments in MAT 085. Each enrollment represented an independent attempt by a student to complete the course, so no one student was enrolled in the same course more than one time in an individual semester. However, individual students could and often did account for more than one of these enrollments. There were a total of 9,440 individual students represented in these data.

Data Collection Methodology

After submitting the project proposal to Murray State University's Institutional Review Board (IRB), a request for historical data was made to SCC. The project was deemed to be an exempt study by MSU's IRB, and the study was also deemed to be exempt by the KCTCS Human Subjects Review Board because all personally identifiable information was removed from the data set. Following the review process, the school provided data on course enrollments, course grades, date of last attendance for students who failed a remedial mathematics course, and demographic data on anonymous students who had enrolled in at least one remedial mathematics course from the fall 2011 semester through the spring 2016 semester.

Grade data, as has been a common practice in similar research, were used as a proxy for student achievement (Frantzen, 2014). One of the reasons that grade data has been commonly used in similar studies is because they were accessible, standardized across courses, and provided reliable information as to the level of student achievement on course objectives (Driscoll et al., 2012; Frantzen, 2014). The demographic data were used to stratify the sample of students to examine the relative impact of course delivery methodology on student achievement between traditional and non-tradition students. Similarly, the demographic data were also used to focus on the relative impact of delivery medium for part-time versus full-time students.

Finally, the date of last attendance for students who failed a course was used to separate students who completed the course from those who did not complete the course. Students whose last date of attendance was more than one week before the end of the semester, implying that a final exam was not taken, were classified as non-completers. The motivation for this consideration was the significant impact that Ashby et al (2011) found between relative student success when non-completing students were eliminated from the population.

Data Analysis

The first five research questions stated in Chapter 1, which each considered the distribution of course grades between students who took the course online versus students who took the course utilizing traditional course delivery methodology, were addressed using the Pearson's Chi-square Test (Field, 2013; Howell, 2004; Starnes, Tabor, Yates, & Moore, 2015). Furthermore, each of the five questions were analyzed separately for MAT 055, MAT 065, and MAT 085. In the first four questions, the Pearson's chi-square test for independence was appropriate for the analysis because there were two categorical variables (delivery method and course grade) and the question sought to determine if the observable differences in the frequency of each grade are statistically significant. In the fifth question, the Pearson's chi-square test for a difference in two proportions was used (Field, 2013; Howell, 2004; Starnes et al., 2015).

Attempts to analyze a relationship between two categorical variables has often been accomplished using a Chi-square Test. The null hypothesis for a Chi-square Test, which stated that the two variables were independent, was analyzed against the alternative hypothesis that the two variables were not independent. In order to accomplish this, the test compared an expected distribution, which would occur if the two variables were actually independent, to the observed distribution. If the difference between the two distributions was great enough, as measured by the Chi-square Test statistic, then the difference between the observed and expected distributions was statistically significant. In such a case, the categorical variables were not independent and, thus, were related (Field, 2013; Howell, 2004; Starnes et al., 2015). Because there are twelve Chi-square tests that consider the grade distribution for each remedial course, there was some possibility of alpha slippage in this study. Therefore, the researcher utilized the Bonferroni correction to establish a level of significance of $\alpha = .004$ on each analysis of the first four research questions (Goldman, 2008). Because the hypothesis was different in Research Question 5, that analysis used an $\alpha = 0.05$ level of significance.

Chi-square tests have two primary assumptions, which were reasonable to make given the data used in this study. First, the values in each cell of the appropriate contingency tables must have been independent (Field, 2013; Howell, 2004; Starnes et al., 2015). For this study, each frequency count represented one student enrollment during a specified semester of a remedial mathematics course. No student was enrolled in more than one attempt of the same course during a given semester. The second assumption is that the expected count in each cell of the contingency table must have been at least five (Field, 2013; Howell, 2004; Starnes et al., 2015). Given the magnitude of the data set, it was reasonable to expect that a least five students earned each possible grade in both online and traditionally delivered courses.

Rather than having samples sizes that are too small, the researcher was more concerned about the large sample size. Frequency values in large sample sizes can reveal significant results even if the effects are relatively small (Field, 2013; Howell, 2004). A more conservative view was to look at row and column percentages in the interpretation of any significant effects (Field, 2013). Therefore, when this study revealed significant results, the magnitude of the effects were interpreted by considering the odds ratio. The odds ratio is a measure of the relative likelihood of an event occurring in two different categories, and it was computed as the quotient of the odds of one event in one population with the odds of another event in the other population (Field, 2013). The odds ratio provided information about the effect size of a result, but the researcher did not find any accepted means for classifying an effect as small, medium, or large based on the odds ratio.

The final two research questions, which addressed potential differences in the proportion of students retained in a mathematics course and the proportion of students who persist through remedial mathematics courses and earn a passing grade in a college-level mathematics course, could also have theoretically been answered using a Pearson's Chi-square Test. However, the format of the data obtained would have made this test extremely difficult to conduct. Therefore, these questions were analyzed using a Z-test for the difference in two proportions with an establish level of significance of $\alpha = 0.05$.

The Z-test for the difference in proportions compared the difference in the proportions of two populations against a null hypothesis, which assumed that there was no difference in the proportions of the two populations, using a sampling distribution. When the magnitude of the difference was great enough, then the sample was significantly different from the null hypothesis. In such an event, the difference observed in the proportions of the two samples was statistically significant and the alternative hypothesis, that the difference was not zero, was accepted (Starnes et al., 2015). This tests assumed a random sample of appropriate size, which can be obtained from the population using IBM's SPSS software. For the Z-test to be valid, it was assumed that the sample size was small enough, relative to the population, so that the probability of an event occurring using selection without replacement was essentially the same as the probability of an event occurring if the sample was made using selection with replacement.

This independence of probabilities condition required that the sample size be not more than one-tenth of the total population size; however, to ensure the normality assumption of the Z-test, the sample must have been great enough that at least ten observations of each possible outcome could be recorded (Starnes et al., 2015). For any of the analyses of the final two research questions that were statistically significant, the effect size was considered using both the odds ratio and Cramer's phi. The odds ratio was defined above, but Cramer's phi is a standardized measure of effect size with possible values between zero and one. For Cramer's phi, the effect size was considered small for values of 0.1, medium for values of 0.3, and large for values of 0.5 (Field, 2013).

To answer research question six, random samples of a specified percentage of the population were obtained and analyzed to determine if there was a significant difference in the proportion of students who completed the given semester or who were retained in a mathematics course the following semester, respectively. While individual students often accounted for more than one enrollment in the data, the sample taken was for an individual enrollment and not for an individual student.

Research question seven was answered differently. Because the definition of persistence necessitated that a student earns a college-level mathematics credit after completing MAT 085, a random sample was taken only of students who successfully completed MAT 085. The proportion of these students who earned a college-level mathematics credit was compared using a Z-test for the difference in two proportions based on the delivery methodology of the student's MAT 085 course regardless of the delivery methodology of the college-level mathematics course.

Chapter 4

Findings and Analysis

The primary purpose of this study was to examine the relative effectiveness of online versus face-to-face delivery methodology on student success in remedial mathematics courses. The population for this study was each enrollment in a remedial mathematics course, defined as MAT 055, MAT 065, or MAT 085, taken at SCC between the Fall 2011 and Spring 2016 semesters. This population consisted of data from 9,440 anonymous students who comprised 20,365 individual course enrollments during the identified time period.

The primary research question, which was used as the foundation of the study in an effort to address the purpose of the study was: *How does student achievement, retention, and persistence compare in remedial mathematics courses between online and traditional delivery methods?* To facilitate answering this question, each remedial course, MAT 055, MAT 065, and MAT 085 was analyzed separately using six research questions. In addition, student enrollments in MAT 085 were used to answer a seventh research question. These seven research questions were:

1. Is there a significant difference in the distribution of course grades between remedial mathematics courses taught using online versus traditional methods?
2. Is there a significant difference in the distribution of course grades between remedial mathematics courses taught using online versus traditional methods if only students who complete the course are considered?
3. Is there a significant difference in the distribution of course grades between remedial mathematics courses taught using online versus traditional methods for traditional and non-traditional students?

4. Is there a significant difference in the distribution of course grades between remedial mathematics courses taught using online versus traditional methods for part-time or full-time students?
5. Is there a significant difference in the proportion of students who complete remedial mathematics courses between students taught using online versus traditional methods?
6. Is there a significant difference in the proportion of students retained in a mathematics course the following semester between remedial mathematics courses taught using online versus traditional methods?
7. Is there a significant difference in the proportion of students who persist in earning a college-level mathematics credit between students enrolled in MAT 085 courses taught using online versus traditional methods?

Description of Information Collected

Data on student enrollments were requested and obtained from SCC for all enrollments of a student in any remedial mathematics course offered by the school from the Fall 2011 through the Spring 2016 semesters. These data included the catalog number and term in which the course was offered, the student's age at the time of the offering, the student's academic load (part-time or full-time), the grade that each student earned in the course, the delivery methodology for the course, and a generated, anonymous student identifier. In addition, the last date of attendance for all students who failed the course was requested. Matthew Jones, Coordinator of the Office of Independent Effectiveness and Research at SCC, stated that the last date of attendance information was missing from a substantial number of the students who received a failing grade (M. Jones, personal communication, November 1, 2016). The last dates of attendance that were available, however, were included with the data.

For each of the remedial classes, MAT 055, MAT 065, and MAT 085, offered at SCC, the only valid passing grades were A, B, and C (M. Jones, personal communication, November 1, 2016). For this reason, although the data provided does contain a few scores of D or MP, which indicated that the student was making progress in the course but did not earn a passing score, each of these cases is included in the appropriate distribution along with all of the other failing grades.

Research Questions

This study addressed the relative effectiveness of online versus face-to-face instructional methodology for remedial mathematics through seven identified research questions. This section details the results of the quantitative analysis of each of these research questions considering individual courses, MAT 055, MAT 065, and MAT 085, separately. These questions were addressed using chi-square tests, and, in each analysis, the assumption that each cell of the associated contingency table contained at least five data points was satisfied.

Research Question 1. Research Question 1 addressed potential differences in the distribution of grades in remedial mathematics courses taught between online and face-to-face methodologies. For this question, the distribution of grades was considered from multiple perspectives in order to fully understand any differences in the distributions. Therefore, for each remedial course, a chi-square test was conducted in order to consider the distribution of only assigned grades A, B, C, D/E/F/MP. Another chi-square test considered only the distribution of passing and failing grades, and a final analysis considered only the distribution of students who earned a credit (A, B, C) compared to those who did not earn a credit (failed or withdrew).

MAT 055. There were a total of 6,445 student enrollments in MAT 055 courses delivered either face-to-face or online at SCC between the Fall 2011 semester and the Spring 2016 semester. The contingency table for the distribution of grades assigned as A, B, C, F is Table 1.

Table 1

Contingency Table of Distribution of A, B, C, D, F Grades for MAT 055

Delivery Methodology	Course Grade				
	A	B	C	F	Total
Face-to-Face	1433	582	18	2561	4594
Online	261	327	149	561	1298
Total	1694	909	167	3122	5892

These data revealed a significant difference between the overall distribution of course grades in MAT 055 ($\chi^2(3) = 615.057, p < .001$). A cursory examination of the contingency table, however, suggested that this difference may have been a result of the extreme differences observed in the distribution of grades A, B, and C. Therefore, a second contingency table was considered which only accounted for passing or failing grades. The contingency table for this distribution is Table 2.

Table 2

Contingency Table of the Distribution of Passing and Failing Grades for MAT 055

Delivery Methodology	Course Grade		
	Pass	Fail	Total
Face-to-Face	2033	2561	4594
Online	737	561	1298
Total	2770	3122	5892

These data also revealed a significant difference in the distribution of passing and failing course grades for MAT 055 ($\chi^2(1) = 63.747, p < .001$). Based on the odds ratio, a student was 1.65 times more likely to earn a passing grade in MAT 055 if the course was taken online rather than taken face-to-face. These data, though, did not account for the number of students who withdrew from the course and, thus, did not earn a grade and also did not earn credit for the course. A final contingency table was analyzed for MAT 055 in which each student enrollment was categorized based only on whether a credit was earned or not. The contingency table for this distribution is Table 3.

Table 3

Contingency Table of the Distribution of Credit Earned for MAT 055

Delivery Methodology	Credit Earned		
	Yes	No	Total
Face-to-Face	2033	3015	5048
Online	737	660	1397
Total	2770	3122	6445

There was a significant difference in the distribution of students earning credit, accounting for each student enrollment, for MAT 055 ($\chi^2(1) = 69.568, p < .001$). Based on the odds ratio, a student was 1.66 times more likely to earn a credit in MAT 055 if the course was taken online rather than taken face-to-face.

MAT 065. There were a total of 7,252 student enrollments in MAT 065 courses delivered either face-to-face or online at SCC between the Fall 2011 semester and the Spring

2016 semester. The contingency table for the distribution of grades assigned as A, B, C, F is Table 4.

Table 4

Contingency Table of Distribution of A, B, C, F Grades for MAT 065

Delivery Methodology	Course Grade				
	A	B	C	F	Total
Face-to-Face	1056	958	46	2656	4716
Online	179	384	221	954	1738
Total	1235	1342	267	3610	6454

These data revealed a significant difference between the overall distribution of course grades in MAT 065 ($\chi^2(3) = 522.582, p < .001$). The extreme differences observed in the distribution of passing grades in Table 4 prompted a second chi-square test considering only passing or failing scores. The contingency table for this distribution is Table 5.

These data did not reveal a significant difference in the distribution of passing and failing course grades for MAT 065 ($\chi^2(1) = 1.051, p = .305$). However, these data did not account for the number of students who withdrew from the course and, thus, did not earn a grade and also did not earn credit for the course.

Table 5

Contingency Table of the Distribution of Passing and Failing Grades for MAT 065

Delivery Methodology	Course Grade		
	Pass	Fail	Total
Face-to-Face	2060	2656	4716
Online	784	954	1738
Total	2844	3610	6454

A final contingency table was analyzed for MAT 065 that grouped each student enrollment based on whether a credit was earned or not. The contingency table for this distribution is Table 6. There was also not a significant difference in the distribution of students earning credit, accounting for each student enrollment, for MAT 065 ($\chi^2(1) = 0.382, p = 0.537$).

Table 6

Contingency Table of the Distribution of Credit Earned for MAT 065

Delivery Methodology	Credit Earned		
	Yes	No	Total
Face-to-Face	2060	3222	5282
Online	784	1186	1970
Total	2844	4408	7252

MAT 085. There were a total of 2,900 student enrollments in MAT 085 courses delivered either face-to-face or online at SCC between the Fall 2011 semester and the Spring 2016 semester. The contingency table for the distribution of grades assigned as A, B, C, F is Table 7.

Table 7

Contingency Table of Distribution of A, B, C, D, F Grades for MAT 085

Delivery Methodology	Course Grade				
	A	B	C	F	Total
Face-to-Face	341	398	39	947	1725
Online	90	173	105	366	734
Total	431	571	144	1313	2459

These data did show a significant difference in the overall distribution of course grades in MAT 085 ($\chi^2(3) = 146.604, p < .001$). The substantial differences evident in the distribution of passing grades in Table 7 prompted a second chi-square test considering only passing or failing scores. The contingency table for this distribution is Table 8.

These data did reveal a significant difference in the distribution of passing and failing course grades for MAT 085 ($\chi^2(1) = 5.245, p = .022$). Based on the odds ratio, a student was 1.13 times more likely to earn a credit in MAT 085 if the course was taken online rather than taken face-to-face.

Table 8

Contingency Table of the Distribution of Passing and Failing Grades for MAT 085

Delivery Methodology	Course Grade		
	Pass	Fail	Total
Face-to-Face	778	947	1725
Online	368	366	734
Total	1146	1313	2459

A final contingency table was analyzed for MAT 085 which grouped each student enrollment based only on whether a credit was earned or not. The contingency table for this distribution is Table 9. There was not a significant difference in the distribution of students earning credit, accounting for each student enrollment, for MAT 085 ($\chi^2(1) = 2.272, p = 0.132$).

Research Question 2. To consider the distribution of course grades based on students who completed the course, this study elected to consider a student as having completed the course if the student either passed the course or had a last reported date of attendance within the final ten days of the semester. The data received from SCC, however, was missing this date from 389 of the 4,806 records in which a student failed a remedial mathematics course. The distribution of these 389 records with missing last dates of attendance was initially examined to determine if they were evenly distributed between online and face-to-face sections. The contingency table for these data is Table 10.

Table 9

Contingency Table of the Distribution of Credits Earned for MAT 085

Delivery Methodology	Credit Earned		
	Yes	No	Total
Face-to-Face	778	1237	2015
Online	368	517	885
Total	1146	1754	2900

Table 10

Contingency Table of the Distribution of Missing Last Date of Attendance Records

Delivery Methodology	Last Date of Attendance		
	Missing	Present	Total
Face-to-Face	165	3157	3322
Online	224	1260	1484
Total	389	4417	4806

The chi-square test showed a significant difference in the proportion of missing final dates of attendance between online and traditionally delivered courses ($\chi^2(1) = 141.430, p < .001$). Based on the odds ratio, a student was 3.40 times more likely, if the student failed a remedial mathematics course, to have a missing last date of attendance if the student had taken the course online rather than in a face-to-face section.

Because the number of students with missing records was only 8.1% of the entire population of students who failed a remedial mathematics course, and because there was no evidence that students who failed but did not have a last date of attendance reported did not actually complete the course, the analysis for Research Question 2 was conducted by grouping the students who failed but have missing last dates of attendance with the students who completed the course. In addition, the analysis of Research Question 1 revealed obvious differences in the distribution of passing grades for each of MAT 055, MAT 065, and MAT 085; therefore, for Research Question 2 only the distribution of passing and failing grades were considered because the trimmed sample had no impact on students with passing grades.

MAT 055. Of the 6,445 total student enrollments in MAT 055 courses delivered either face-to-face or online at SCC between the Fall 2011 semester and the Spring 2016 semester, there were 4,346 students who completed the course as defined in this study. The contingency table for the distribution of passing and failing grades for students who completed MAT 055 is Table 11.

Table 11

Contingency Table of the Distribution of Passing and Failing Grades for MAT 055 for Students Who Completed the Course

Delivery Methodology	Course Grade		
	Pass	Fail	Total
Face-to-Face	2033	1375	3408
Online	737	201	938
Total	2770	1576	4346

These data did reveal a significant difference in the distribution of passing and failing course grades for students who completed MAT 055 ($\chi^2(1) = 113.892, p < .001$). Based on the odds ratio, a student was 2.48 times more likely to earn a passing grade in MAT 055 if the course was taken online rather than taken face-to-face.

MAT 065. Of the total of 7,252 student enrollments in MAT 065 courses delivered either face-to-face or online at SCC between the Fall 2011 semester and the Spring 2016 semester, there were a total of 4,897 students who completed the course. The contingency table for the distribution of passing and failing grades assigned in MAT 065 for students who completed the course is Table 12. There was not a significant difference in the distribution of students earning a passing grade, when only students who completed the course were considered, for MAT 065 ($\chi^2(1) = 2.422, p = .120$).

Table 12

Contingency Table of the Distribution of Passing and Failing Grades for MAT 065 for Students Who Completed the Course

Delivery Methodology	Course Grade		
	Pass	Fail	Total
Face-to-Face	2060	1528	3588
Online	784	525	1309
Total	2844	2053	4897

MAT 085. Of the 2,900 total student enrollments in MAT 085 courses delivered either face-to-face or online at SCC between the Fall 2011 semester and the Spring 2016 semester, there were 1,886 students who completed the course. The contingency table for the distribution of passing and failing grades is Table 13

There was a significant difference in the distribution of students earning a passing grade, when only students who completed the course were considered, for MAT 085 ($\chi^2(1) = 16.764, p$

< .001). Based on the odds ratio, a student who completed the course was 1.55 times more likely to earn a passing grade in MAT 085 if the course was taken online rather than taken face-to-face.

Table 13

Contingency Table of the Distribution of Passing and Failing Grades for MAT 085 for Students Who Completed the Course

Delivery Methodology	Course Grade		
	Pass	Fail	Total
Face-to-Face	778	567	1345
Online	368	173	541
Total	1146	740	1886

Research Question 3. The third research question for this study examined the relative impact of online compared to face-to-face instruction in remedial mathematics courses on traditional and non-traditional students. Traditional students for the purpose of this analysis were defined as students between the ages of 18 and 24, and non-traditional students were those students who were at least 25 years old at the time of the course. For each remedial mathematics course offered by SCC, the distribution of passing and failing grades were analyzed for traditional students between online and in-person sections, for non-traditional students between online and in-person sections, for in-person sections between traditional and non-traditional students, and finally for online sections between traditional and non-traditional students.

MAT 055. During the time of this study, there were 2,762 traditional student enrollments in MAT 055 which resulted in a passing or failing grade omitting students who withdrew from the course. The contingency table for the distribution of passing and failing grades for these students is Table 14.

There was a significant difference in the distribution of students earning a passing grade, when only traditional students were considered, for MAT 055 ($\chi^2(1) = 17.941, p < .001$). Based on the odds ratio, a traditional student was 1.52 times more likely to earn a passing grade in MAT 055 if the course was taken online rather than taken face-to-face.

Table 14

Contingency Table of the Distribution of Passing and Failing Grades for MAT 055 for Traditional Students

Delivery Methodology	Course Grade		
	Pass	Fail	Total
Face-to-Face	929	1328	2257
Online	260	245	505
Total	1189	1573	2762

There were another 3,130 non-traditional student enrollments in MAT 055 which resulted in a passing or failing grade when the students who withdrew were omitted. The contingency table for the distribution of passing and failing grades for these students is Table 15.

Table 15

Contingency Table of the Distribution of Passing and Failing Grades for MAT 055 for Non-Traditional Students

Delivery Methodology	Course Grade		
	Pass	Fail	Total
Face-to-Face	1104	1233	2337
Online	477	316	793
Total	1581	1549	3130

There was a significant difference in the distribution of students earning a passing grade, when only non-traditional students were considered, for MAT 055 ($\chi^2(1) = 39.485, p < .001$).

Based on the odds ratio, a non-traditional student was 1.69 times more likely to earn a passing grade in MAT 055 if the course was taken online rather than taken face-to-face.

The previous two contingency tables addressed the relative differences between online and face-to-face remedial mathematics courses when traditional or non-traditional students are considered independently. Additionally, analysis was conducted on the difference between traditional and non-traditional student performance in online sections and then, separately, in face-to-face sections. The contingency table for the distribution of passing and failing grades for face-to-face sections with students categorized as traditional or non-traditional in MAT 055 is Table 16.

Table 16

Contingency Table of the Distribution of Passing and Failing Grades for MAT 055 for Face-to-Face Sections

Student Classification	Course Grade		
	Pass	Fail	Total
Traditional	929	1328	2257
Non-Traditional	1104	1233	2337
Total	2033	2561	4594

There was a significant difference in the distribution of students earning a passing grade in face-to-face delivered sections when students were divided into traditional and non-traditional groups, for MAT 055 ($\chi^2(1) = 17.200, p < .001$). Based on the odds ratio, a non-traditional student was 1.28 times more likely to earn a passing grade in a face-to-face section of MAT 055 than a traditional student.

The contingency table for the distribution of passing and failing grades for online sections with students categorized as traditional or non-traditional is Table 17. There was a significant difference in the distribution of students earning a passing grade in online delivered sections when students were divided into traditional and non-traditional groups, for MAT 055 ($\chi^2(1) = 9.442, p = .002$). A non-traditional student, as measured by the odds ratio was 1.42 times more likely to earn a passing grade in an online section of MAT 055 than a traditional student.

Table 17

Contingency Table of the Distribution of Passing and Failing Grades for MAT 055 for Online Delivered Sections

Student Classification	Course Grade		
	Pass	Fail	Total
Traditional	260	245	505
Non-Traditional	477	316	793
Total	737	561	1298

MAT 065. During the time of this study, there were 3,160 traditional student enrollments in MAT 065 which resulted in a passing or failing grade omitting students who withdrew from the course. The contingency table for the distribution of passing and failing grades for these students is Table 18. There was not a significant difference in the distribution of students earning a passing grade, when only traditional students were considered, for MAT 065 ($\chi^2(1) = 2.817, p = .093$).

There were another 3,294 non-traditional student enrollments in MAT 065, which resulted in a passing or failing grade omitting the students who withdrew. The contingency table for the distribution of passing and failing grades for these students is Table 19. There was not a significant difference in the distribution of students earning a passing grade, when only non-traditional students were considered, for MAT 065 ($\chi^2(1) = 0.458, p = .499$).

Table 18

Contingency Table of the Distribution of Passing and Failing Grades for MAT 065 for Traditional Students

Delivery Methodology	Course Grade		
	Pass	Fail	Total
Face-to-Face	1045	1484	2529
Online	284	347	631
Total	1329	1831	3160

Table 19

Contingency Table of the Distribution of Passing and Failing Grades for MAT 065 for Non-Traditional Students

Delivery Methodology	Course Grade		
	Pass	Fail	Total
Face-to-Face	1015	1172	2187
Online	500	607	1107
Total	1515	1779	3294

While the two previous chi-square tests addressed the relative differences in the distribution of passing and failing grades between face-to-face and online sections of MAT 065 for traditional and non-traditional students separately, additional analysis was conducted to consider the relative differences in the distribution of passing and failing grades between traditional and non-traditional students in face-to-face and then online sections, respectively. The contingency table for the distribution of passing and failing grades for face-to-face sections with students categorized as traditional or non-traditional in MAT 065 is Table 20.

There was a significant difference in the distribution of students earning a passing grade in face-to-face delivered sections when students were divided into traditional and non-traditional groups, for MAT 065 ($\chi^2(1) = 12.351, p < .001$). Based on the odds ratio, a non-traditional student was 1.23 times more likely to earn a passing grade in an in-person section of MAT 065 than a traditional student.

Table 20

Contingency Table of the Distribution of Passing and Failing Grades for MAT 065 for Face-to-Face Sections

Student Classification	Course Grade		
	Pass	Fail	Total
Traditional	1045	1484	2529
Non-Traditional	1015	1172	2187
Total	2060	2656	4716

The contingency table for the distribution of passing and failing grades for online sections with students categorized as traditional or non-traditional for MAT 065 is Table 21.

Table 21

Contingency Table of the Distribution of Passing and Failing Grades for MAT 065 for Online Delivered Sections

Student Classification	Course Grade		
	Pass	Fail	Total
Traditional	284	347	631
Non-Traditional	500	607	1107
Total	784	954	1738

There was not a significant difference in the distribution of students earning a passing grade in online delivered sections when students were divided into traditional and non-traditional groups, for MAT 065 (χ^2*(1) = .004, p = .949).*

MAT 085. There were 1,249 traditional student enrollments in MAT 085 during the time of this study which resulted in a passing or failing grade omitting students who withdrew from the course. The contingency table for the distribution of passing and failing grades for these students is Table 22. There was not a significant difference in the distribution of students earning a passing grade, when only traditional students were considered, for MAT 085 (χ^2*(1) = 3.266, p = .071).*

Table 22

Contingency Table of the Distribution of Passing and Failing Grades for MAT 085 for Traditional Students

Delivery Methodology	Course Grade		
	Pass	Fail	Total
Face-to-Face	416	532	948
Online	150	151	301
Total	566	683	1249

There were another 1,210 non-traditional student enrollments in MAT 085 which resulted in a passing or failing grade omitting the students who withdrew. The contingency table for the distribution of passing and failing grades for these students is Table 23. There was not a statistically significant difference in the distribution of students earning a passing grade, when only non-traditional students were considered, for MAT 085 (χ^2*(1) = 1.573, p = .210).*

The two previous chi-square tests addressed the relative differences in the distribution of passing and failing grades between face-to-face and online sections of MAT 085 for traditional and non-traditional students separately. Additional analysis was conducted to consider the relative differences in the distribution of passing and failing grades between traditional and non-traditional students in face-to-face and then online sections, respectively. The contingency table for the distribution of passing and failing grades for face-to-face sections with students categorized as traditional or non-traditional in MAT 085 is Table 24.

Table 23

Contingency Table of the Distribution of Passing and Failing Grades for MAT 085 for Non-Traditional Students

Delivery Methodology	Course Grade		
	Pass	Fail	Total
Face-to-Face	362	415	777
Online	218	215	433
Total	580	630	1210

Table 24

Contingency Table of the Distribution of Passing and Failing Grades for MAT 085 for Face-to-Face Sections

Student Classification	Course Grade		
	Pass	Fail	Total
Traditional	416	532	948
Non-Traditional	362	415	777
Total	778	947	1725

There was not a significant difference in the distribution of students earning a passing grade in face-to-face delivered sections when students were divided into traditional and non-traditional groups, for MAT 085 ($\chi^2(1) = .264, p = .261$).

The contingency table for the distribution of passing and failing grades for online sections with students categorized as traditional or non-traditional for MAT 085 is Table 25. There was not a significant difference in the distribution of students earning a passing grade in online delivered sections when students were divided into traditional and non-traditional groups, for MAT 085 ($\chi^2(1) = .019, p = .891$).

Table 25

Contingency Table of the Distribution of Passing and Failing Grades for MAT 085 for Online Delivered Sections

Student Classification	Course Grade		
	Pass	Fail	Total
Traditional	150	151	301
Non-Traditional	218	215	433
Total	368	366	734

Research Question 4. This study's fourth research question considered the relative impact on full-time versus part-time students of online compared to face-to-face instruction in remedial mathematics courses. SCC classified each student as either full-time or part-time each semester, and this study used the school's classification for each student. The distribution of passing and failing grades for each remedial mathematics course offered by SCC was analyzed for full-time students between online and in-person sections, for part-time students between online and in-person sections, for in-person sections between full-time and part-time students, and finally for online sections between full-time and part-time students.

MAT 055. During the time of this study, there were 3,490 student enrollments in MAT 055 by students classified as full-time which resulted in a passing or failing grade omitting students who withdrew from the course. The contingency table for the distribution of passing and failing grades for these students is Table 26.

Table 26

Contingency Table of the Distribution of Passing and Failing Grades for MAT 055 for Full-Time Students

Delivery Methodology	Course Grade		
	Pass	Fail	Total
Face-to-Face	1329	1510	2839
Online	391	260	651
Total	1720	1770	3490

There was a significant difference in the distribution of students earning a passing grade, when only full-time students were considered, for MAT 055 ($\chi^2(1) = 37.192, p < .001$). Based on the odds ratio, a full-time student was 1.71 times more likely to earn a passing grade in MAT 055 if the course was taken online rather than taken face-to-face.

There were another 2,400 part-time student enrollments in MAT 055 which resulted in a passing or failing grade omitting the students who withdrew. The contingency table for the distribution of passing and failing grades for these students is Table 27.

Table 27

Contingency Table of the Distribution of Passing and Failing Grades for MAT 055 for Part-Time Students

Delivery Methodology	Course Grade		
	Pass	Fail	Total
Face-to-Face	702	1051	1753
Online	346	301	647
Total	1048	1352	2400

There was a significant difference in the distribution of students earning a passing grade, when only part-time students were considered, for MAT 055 ($\chi^2(1) = 34.661, p < .001$). Based on the odds ratio, a part-time student was 1.72 times more likely to earn a passing grade in MAT 055 if the course was taken online rather than taken face-to-face.

The previous two contingency tables addressed the relative differences between online and face-to-face remedial mathematics courses when full-time or part-time students are considered independently. Additionally, analysis was conducted on the relative effect on student performance in online sections and then, separately, in face-to-face sections between full-time and part-time students. The contingency table for the distribution of passing and failing grades for face-to-face sections with students categorized as full-time or part-time in MAT 055 is Table 28.

Table 28

Contingency Table of the Distribution of Passing and Failing Grades for MAT 055 for Face-to-Face Sections

Student Classification	Course Grade		
	Pass	Fail	Total
Full-Time	1329	1510	2839
Part-Time	702	1051	1753
Total	2031	2561	4592

There was a significant difference in the distribution of students earning a passing grade in face-to-face delivered sections when students were divided into full-time and part-time categories, for MAT 055 ($\chi^2(1) = 20.117, p < .001$). Based on the odds ratio, a full-time student was 1.32 times more likely to earn a passing grade in an in-person section of MAT 055 than a traditional student. The contingency table for the distribution of passing and failing grades for online sections with students categorized full-time or part-time is Table 29.

Table 29

Contingency Table of the Distribution of Passing and Failing Grades for MAT 055 for Online Delivered Sections

Student Classification	Course Grade		
	Pass	Fail	Total
Full-Time	391	260	651
Part-Time	346	301	647
Total	737	561	1298

There was a significant difference in the distribution of students earning a passing grade in online delivered sections when students were divided into full-time and part-time categories, for MAT 055 ($\chi^2(1) = 5.732, p < .001$). Based on the odds ratio, a full-time student was 1.31 times more likely to earn a passing grade in an online section of MAT 055 than a part-time student.

MAT 065. During the time of this study, there were 3,739 full-time student enrollments in MAT 065 which resulted in a passing or failing grade omitting students who withdrew from the course. The contingency table for the distribution of passing and failing grades for these students is Table 30.

There was a significant difference in the distribution of students earning a passing grade, when only full-time students were considered, for MAT 065 ($\chi^2(1) = 5.395, p = .020$). A full-time student enrolled on MAT 065 was, based on the odds ratio, 1.19 times more likely to earn a passing grade if the course was taken in an online as opposed to face-to-face delivered section.

Table 30

Contingency Table of the Distribution of Passing and Failing Grades for MAT 065 for Full-Time Students

Delivery Methodology	Course Grade		
	Pass	Fail	Total
Face-to-Face	1385	1494	2879
Online	451	409	860
Total	1836	1903	3739

There were another 2,712 part-time student enrollments in MAT 065 which resulted in a passing or failing grade omitting the students who withdrew. The contingency table for the distribution of passing and failing grades for these students is Table 31. There was not a significant difference in the distribution of students earning a passing grade, when only part-time students were considered, for MAT 065 ($\chi^2(1) = 0.294, p = .588$).

Table 31

Contingency Table of the Distribution of Passing and Failing Grades for MAT 065 for Part-Time Students

Delivery Methodology	Course Grade		
	Pass	Fail	Total
Face-to-Face	674	1162	1836
Online	331	545	876
Total	1005	1707	2712

In addition to considering the relative differences between online and face-to-face instruction in remedial mathematics courses for full-time and part-time students independently, the relative difference between full-time and part-time students was analyzed between face-to-face and online courses separately. The contingency table for the distribution of passing and failing grades for face-to-face sections with students categorized as full-time or part-time in MAT 065 is Table 32.

Table 32

Contingency Table of the Distribution of Passing and Failing Grades for MAT 065 for Face-to-Face Delivered Sections

Student Classification	Course Grade		
	Pass	Fail	Total
Full-Time	1385	1494	2879
Part-Time	674	1162	1836
Total	2059	2656	4715

There was a significant difference in the distribution of students earning a passing grade in face-to-face delivered sections when students were divided into full-time and part-time categories, for MAT 065 ($\chi^2(1) = 59.193, p < .001$). Based on the odds ratio, a full-time student was 1.60 times more likely to earn a passing grade in an in-person section of MAT 065 than a part-time student.

The contingency table for the distribution of passing and failing grades for online sections with students categorized full-time or part-time is Table 33. There was a significant difference in the distribution of students earning a passing grade in face-to-face delivered sections when students were divided into full-time and part-time categories, for MAT 065 ($\chi^2(1) = 37.658, p < .001$). Based on the odds ratio, a full-time student was 1.82 times more likely to earn a passing grade in an online section of MAT 065 than a part-time student.

MAT 085. There were 1,263 enrollments in MAT 085 by full-time students during the time of this study which resulted in a passing or failing grade omitting students who withdrew from the course. The contingency table for the distribution of passing and failing grades for these students is Table 34. There was not a significant difference in the distribution of students earning a passing grade, when only full-time students were considered, for MAT 085 ($\chi^2(1) = .554, p = .457$).

Table 33

Contingency Table of the Distribution of Passing and Failing Grades for MAT 055 for Online Delivered Sections

Student Classification	Course Grade		
	Pass	Fail	Total
Full-Time	451	409	860
Part-Time	331	545	876
Total	782	954	1736

Table 34

Contingency Table of the Distribution of Passing and Failing Grades for MAT 085 for Full-Time Students

Delivery Methodology	Course Grade		
	Pass	Fail	Total
Face-to-Face	478	462	940
Online	172	151	323
Total	650	613	1263

There were another 1,196 part-time student enrollments in MAT 085 which resulted in a passing or failing grade omitting the students who withdrew. The contingency table for the distribution of passing and failing grades for these students is Table 35.

There was a significant difference in the distribution of students earning a passing grade, when only part-time students were considered, for MAT 085 ($\chi^2(1) = 9.971, p = .002$). A part-time student who was enrolled in MAT 085 in an online section was 1.47 times more likely, according to the odds ratio, to earn a passing grade than a part-time student enrolled in a face-to-face delivered section.

Table 35

Contingency Table of the Distribution of Passing and Failing Grades for MAT 085 for Part-Time Students

Delivery Methodology	Course Grade		
	Pass	Fail	Total
Face-to-Face	300	485	785
Online	196	215	411
Total	496	700	1196

The two previous chi-square tests addressed the relative differences in the distribution of passing and failing grades between face-to-face and online sections of MAT 085 for full-time and part-time students separately. Additional analysis was conducted to consider the relative differences in the distribution of passing and failing grades between part-time and full-time students in face-to-face and then online sections, respectively. The contingency table for the distribution of passing and failing grades for face-to-face sections with students categorized as full-time or part-time in MAT 085 is Table 36.

There was a significant difference in the distribution of students earning a passing grade in face-to-face delivered sections when students were divided into full-time and part-time groups for MAT 085 ($\chi^2(1) = 27.579, p < .001$). Based on the odds ratio, a full-time student was 1.67

times more likely to earn a passing grade in MAT 085 taken in a face-to-face section than a part-time student.

Table 36

Contingency Table of the Distribution of Passing and Failing Grades for MAT 085 for Face-to-Face Sections

Student Classification	Course Grade		
	Pass	Fail	Total
Full-Time	478	462	940
Part-Time	300	485	785
Total	778	947	1725

The contingency table for the distribution of passing and failing grades for online sections with students categorized as full-time or part-time for MAT 085 is Table 37.

Table 37

Contingency Table of the Distribution of Passing and Failing Grades for MAT 085 for Online Delivered Sections

Student Classification	Course Grade		
	Pass	Fail	Total
Full-Time	172	151	323
Part-Time	196	215	411
Total	368	366	734

There was not a significant difference in the distribution of students earning a passing grade in online delivered sections when students were divided into full-time and part-time groups, for MAT 085 ($\chi^2(1) = 2.238, p = .135$).

Research Question 5. The fifth research question concerned the completion rate for students enrolled in online as compared to face-to-face sections of remedial mathematics courses. A student was considered to have completed a course if either the student earned a passing grade in the course or the student's reported last date of attendance was within the last ten days of the given semester. All students who withdrew from a course were classified as not completing the course.

MAT 055. There were a total of 6,447 students enrolled in MAT 055 at SCC during the dates of this study. The contingency table comparing the delivery method and course completion status for these students is Table 38. There was not a significant difference in the proportion of students completing MAT 055, ($\chi^2(1) = .645, p = .799$), between those who took the course online as compared to a face-to-face delivered section.

Table 38

Contingency Table of the Distribution of Course Completion for MAT 055 Categorized by Delivery Methodology

Delivery Methodology	Course Completion		
	Completed	Not Completed	Total
Face-to-Face	3409	1641	5050
Online	938	459	1397
Total	4347	2100	6447

MAT 065. During the dates of this study, there were a total of 7,262 students enrolled in either an online or face-to-face section of MAT 065 at SCC. The contingency table comparing the delivery method and course completion status for these students is Table 39. There was not a significant difference in the proportion of students completing MAT 065, ($\chi^2(1) = 1.132, p = .287$), between those who took the course online as compared to a face-to-face delivered section.

Table 39

Contingency Table of the Distribution of Course Completion for MAT 065 Categorized by Delivery Methodology

Delivery Methodology	Course Completion		
	Completed	Not Completed	Total
Face-to-Face	3588	1694	5282
Online	1319	661	1980
Total	4907	2355	7262

MAT 085. There were a total of 2,900 students enrolled in either an online or face-to-face section of MAT 085 at SCC between the Fall 2011 and Spring 2016 semesters. The contingency table comparing the delivery method and course completion status for these students is Table 40.

Table 40

Contingency Table of the Distribution of Course Completion for MAT 085 Categorized by Delivery Methodology

Delivery Methodology	Course Completion		
	Completed	Not Completed	Total
Face-to-Face	1345	670	2015
Online	541	344	885
Total	1886	1014	2900

There was a significant difference in the proportion of students completing MAT 085, ($\chi^2(1) = 8.539, p = .003$), between those who took the an online as compared to a face-to-face delivered section. Based on the odds ratio, a student was 1.28 times more likely to complete

MAT 085 if the student was enrolled in a face-to-face delivered section as compared to a student enrolled in an online delivered section.

Research Question 6. In order to consider the relative proportion of students who were retained, considering MAT 055, MAT 065, and MAT 085 separately, a random sample of student enrollments was selected from the population of enrollments for each course. For each enrollment, the student was judged to have been retained if the student was enrolled in any math class the semester following the semester represented by the randomly selected enrollment. A Z-test for the difference in two proportions was conducted on each of these random samples, and the results are reported below.

MAT 055. IBM's SPSS software was used to select a random sample of approximately 3% of the total number of student enrollments in MAT 055 contained within the scope of this study. This sample size was appropriate to maintain the independence assumption of the Z-test. There were eight student enrollments in this random sample which occurred in the Spring 2016 semester, which is the last semester of the study. Therefore, these students were omitted from the sample because the data were not able to show either retention or a lack of retention. The normality assumption for the Z-test was met because there were at least five students retained and five students not retained in both traditionally delivered and online sections of the course.

In the sample for MAT 055, 82 out of 156 students enrolled in traditionally delivered sections and 9 out of 40 students enrolled in online sections were retained into a mathematics course at SCC the following semester. These proportions show a significant difference ($Z = 3.401, p < .001$) between the retention rate of face-to-face and online students in MAT 055. Based on the odds ratio, a student enrolled in a face-to-face delivered section was 3.82 times more likely to be retained than a student enrolled in an online section of the course; however, the effect size *(φ=0.243)* suggested a small to moderate practical significance.

MAT 065. A random sample of approximately 2% of the total number of student enrollments in MAT 065 contained within the scope of this study was selected using IBM's SPSS software. This sample size was appropriate to maintain the independence assumption of the Z-test. A total of nine of these student enrollments occurred in the Spring 2016 semester, which was the last semester of the study. For this reason, these students were omitted from the sample because the data were not able to show either retention or a lack of retention. The normality assumption for the Z-test was met because at least five students were retained and not retained for both face-to-face and online sections of the course.

In the sample for MAT 065, 53 out of 101 students enrolled in traditionally delivered sections and 14 out of 33 students enrolled in online sections were retained into a mathematics course at SCC the following semester. There was not a significant difference *($Z = 1.003$ $p = .316$)* in the proportion of students in MAT 065 who were enrolled in traditionally delivered sections as compared with the proportion of students enrolled in online sections of MAT 065.

MAT 085. IBM's SPSS software was used to select a random sample of approximately 5% of the total number of student enrollments in MAT 085 contained within the scope of this study was selected. This sample size was appropriate to maintain the independence assumption of the Z-test. The normality assumption for the Z-test was met because there are at least five students retained and five students not retained for both delivery methodologies. There were nine student enrollments in this random sample which occurred in the Spring 2016 semester, which was the last semester of the study. These students were omitted from the sample because the data were not able to show either retention or a lack of retention.

In the sample for MAT 085, 60 out of 97 students enrolled in traditionally delivered sections and 15 out of 35 students enrolled in online sections were retained into a mathematics course at SCC the following semester. There was not a significant difference *($Z = -1.116$, $p = .265$)* in the proportion of students in MAT 085 who were enrolled in traditionally delivered sections as compared to the proportion of students enrolled in online sections of MAT 085.

Research Question 7. A student in this study was said to persist in remedial mathematics if the student both earned as passing grade in MAT 085 and then earned a credit in any 100-level mathematics course at SCC. The relative proportions of students who persisted to earn a 100-level mathematics course was analyzed using a Z-Test for the difference in two proportions by categorizing students by the type of course in which the student earned a passing grade in MAT 085. A random sample of approximately 5% of the students who earned a passing grade in MAT 085 was selected. This sample size was consistent with the assumption of independence required by the Z-Test. In addition, there were at least five students who persisted and five students who did not persist from both traditionally delivered and online courses, so the assumption of normality was also valid.

In the selected random sample of students who earned a credit in MAT 085, 31 out of 51 students enrolled in traditional sections and 6 out of 20 students enrolled in online sections persisted to earn a 100-level mathematics credit at SCC. The proportion of students in the sample who earned a MAT 085 credit in traditionally delivered sections and persisted was significantly different *($Z = 2.336$, $p =.020$)* than the proportion of students enrolled in online sections of MAT 085 who persisted. A student in a face-to-face section was 1.42 times more likely to persist than a student who earned a MAT 085 credit in an online section of the course; however, the effect size *($\varphi=0.277$)* suggests that the practical significance was small to moderate.

Chapter 5

Summary, Discussion and Conclusions

Advances in educational technology have provided educators with a diverse array of instructional delivery options, but it is incumbent upon educational leaders to select the course delivery opportunities which are best able to meet the needs of the students and goals of the institutions. Educational leaders should be aware of the relative strengths and weaknesses associated with each delivery methodology in order to mitigate weaknesses and provide students with the greatest opportunities for success. There are a substantial number of online remedial mathematics course options for community college students, but the effectiveness of these courses is not well-established in the literature. Therefore, the primary research objective for this study was to examine the relative impact on student achievement, retention, and persistence between remedial mathematics courses delivered in online and face-to-face formats.

Summary of the Literature Review

Technological advances have opened educational opportunities for an increasing number of students. While more than 30% of all college students participate in online courses, asynchronous online courses are particularly attractive to community college students whose non-academic commitments place a premium on the flexibility of time and location provided by these courses (Bambara et al., 2009; Castle & McGuire, 2010; Driscoll et al., 2012; Frantzen, 2014; Summers et al., 2005). Community college students now account for 54% of all online course enrollments, and students participating in online courses are more likely to be non-traditional (Ashby et al., 2011; Bambara et al., 2009; Xu & Jaggars, 2011). While online courses open opportunities for students who may not otherwise have access to post-secondary education, educational leaders are responsible to ensure that these opportunities provide at least equivalent educational experiences (Cooper, 2004).

Beginning with the publication of Russell's (1999) work, the casual understanding among educators was that there is no significant difference in student outcomes based on the delivery methodology. In the years following 1999, though, several issues with the studies previously cited became evident including a student selection bias as well as the fact that the majority of these studies focused on well-prepared students (Frantzen, 2014; Xu & Jaggars, 2011). Little evidence exists to show the relative effectiveness of online education for academically underprepared students (Xu & Jaggars, 2011).

Recent studies, however, continue to suggest that online education can be at least as effective as traditional alternatives (Driscoll et al., 2012; Means et al., 2009). Nguyen (2015), in a detailed meta-analysis, revealed that student achievement in online courses is modestly better than in courses in which a face-to-face delivery methodology was used.

Ashby et al. (2011), one of the few studies closely aligned with this study, conducted an analysis of delivery methodology in community college developmental mathematics courses. This analysis found that students enrolled in face-to-face sections achieved at higher levels than online students. However, when the authors trimmed this sample to only include students who completed the course, online students out-performed face-to-face students because the completion rate was significantly lower among online students in the study (Ashby et al., 2011). Consistent with this work, there is evidence that lower performing students fared better in face-to-face courses than in online courses (Peterson & Bond, 2004).

Beyond student achievement, there are concerns about the impact of online courses on student retention in developmental courses (Zavarella & Ignash, 2009). In a large study of nearly 20,000 community college students, online students had a significantly negative impact on retention and course grade, and students with lower levels of preparation and motivation were more likely to struggle online (Xu & Jaggars, 2011). Successful online students need to be self-regulated learners, but developmental mathematics students are often not self-regulated and lack the educational background to be successful in an online environment (Ashby et al., 2011; Driscoll et al., 2012). As Lack (2013) suggested, the current evidence suggests that educational leaders should assume a cautious approach to online learning.

The poor student success rate in developmental mathematics is a national crisis which is beginning to attract broad attention (Cafarella, 2014). Students' previous mathematical struggles can result in mathematical anxiety or a lack of mathematical self-efficacy which subsequently can have a negative impact on a student's ability to be successful in remedial mathematics sequences that involve multiple remedial courses (Summers et al., 2005). One movement to address this issue has been to adopt a compressed approach to developmental mathematics which reduces the total number of courses that students are required to take (Cafarella, 2014).

Student retention rates are an important consideration in the types of courses offered by educational institutions. Evidence suggests that first-year students, online students, and community college students have relatively lower retention rates (Ashby et al., 2011; Dupin-Bryant, 2004). Student participation in developmental mathematics can result in increased student retention rates among community college students, and this impact can even occur if a student does not pass the developmental course (Fike & Fike, 2008). Wolfle (2012), though, suggests that the impact of developmental mathematics courses may be a result of students participating in small, face-to-face courses which emphasize student integration into college.

Though retention is important for college planning purposes, student persistence to degree or program completion is equally important. Nearly half of all community college students, and a higher percentage of students who begin in developmental courses, drop out before obtaining a degree or credential (Wolfle, 2012). Even for students who pass all prescribed remedial mathematics courses face difficulties in earning a college-level mathematics credit. Some studies show that up to 70% of developmental mathematics students do not ultimately earn a college-level mathematics credit (Bailey et al., 2010; Benken et al., 2015; Wolfle, 2012).

Methodology and Data Analysis

Data were obtained on each student enrollment in a remedial mathematics course (MAT 055, MAT 065, and MAT 085) from SCC for the Fall 2011 semester through the Spring 2016 semester. In order to address the primary research objective, seven more focused research questions were analyzed for each course using appropriate statistical techniques. These seven questions were:

1. Is there a significant difference in the distribution of course grades between remedial mathematics courses taught using online versus traditional methods?
2. Is there a significant difference in the distribution of course grades between remedial mathematics courses taught using online versus traditional methods if only students who complete the course are considered?
3. Is there a significant difference in the distribution of course grades between remedial mathematics courses taught using online versus traditional methods for traditional and non-traditional students?

4. Is there a significant difference in the distribution of course grades between remedial mathematics courses taught using online versus traditional methods for part-time or full-time students?
5. Is there a significant difference in the proportion of students who complete remedial mathematics courses between students taught using online versus traditional methods?
6. Is there a significant difference in the proportion of students retained in a mathematics course the following semester between remedial mathematics courses taught using online versus traditional methods?
7. Is there a significant difference in the proportion of students who persist in earning a college-level mathematics credit between students enrolled in MAT 085 courses taught using online versus traditional methods?

The analysis of each of these research questions separated by each remedial mathematics course, as well as a consideration of the common trends across multiple courses, provides an understanding of the relative effectiveness of online remedial mathematics courses as compared to face-to-face delivered courses. This understanding provides educational leaders with critical information in their efforts to offer students effective remedial opportunities prior to enrolling in college-level mathematics courses.

Summary of Findings

While this study focused on remedial mathematics in general, SCC offers three sequential courses moving students toward 100-level mathematics courses. For this reason, the findings to the identified research questions will first be discussed for each course independently. Following this, the commonalities and differences between the courses from the findings will be discussed.

MAT 055. The initial analyses for MAT 055 examined the distribution of grades between students who took MAT 055 online or in face-to-face sections. These distributions were significantly different, but it was clear that this difference may have been a result of the extreme differences in the distribution of passing grades (A, B, and C). In the face-to-face sections, the passing grades were strongly right-skewed with 1433 A's, 582 B's, and only 18 C's. In contrast, the distribution of passing grades in online sections was approximately symmetric with 261 A's, 327 B's, and 149 C's. Because of these obvious differences, the distribution of grades classifying each as either passing or failing was considered.

There remained a significant difference between online and face-to-face sections in the distribution of passing and failing grades. This analysis showed that students were 1.65 times more likely to earn a passing grade in online sections. Accounting for students who withdrew, and thus still did not earn a credit in the course, the likelihood of an online student passing remained similar at 1.66 times as likely.

Based on the findings of Ashby et al. (2011) which suggested that controlling for students who completed the course increased the relative success of online courses, an analysis of the grade distributions for only students who completed the course was conducted. This analysis showed that a MAT 055 student who completed that course was 2.48 times more likely to earn a passing grade if the student took the course online rather than face-to-face. This is particularly relevant because subsequent analysis showed no significant difference in the completion percentage between students enrolled in online as compared to face-to-face sections of MAT 055.

In addition to considering all students, an analysis of the distribution of grades was conducted considering traditional and non-traditional students as two separate groups. For both groups, the students enrolled in online sections were more likely to earn a passing grade than students enrolled in face-to-face sections. Traditional students were 1.52 times more likely to earn a passing grade in online sections, and non-traditional students were 1.69 times more likely to earn a passing grade in online sections. When traditional and non-traditional students were compared keeping the delivery methodology constant, traditional students were 1.28 times more likely to earn a passing grade in face-to-face sections while non-traditional students were 1.42 times more likely to earn a passing grade in online sections.

An analysis of the relative success of full-time and part-time students was also conducted. In both cases, students were more likely to earn a passing grade in online sections as compared to face-to-face sections. Full-time students were 1.71 times more likely to earn a passing grade in online sections while part-time students were similarly 1.72 times more likely in online sections to earn a passing grade. When comparing full-time to part-time students, the full-time students were more likely than part-time students to earn a passing grade regardless of delivery methodology.

Finally, a random sample of student enrollments was selected to test the null hypothesis. The proportion of students who were retained to take some mathematics course in the following semester was the same whether the student was enrolled in the course online or face-to-face. For MAT 055, there was a significant difference in the rate of retention. In the sample, 52.6% of face-to-face students were retain compared to only 22.5% of online students.

MAT 065. Like the initial analysis in MAT 055, the first analysis of the overall grade distributions showed a significant difference; however, there were extreme differences in the distribution of passing grades for this course as well. As also observed in MAT 055, the distribution of passing grades in MAT 065 was strongly right-skewed with 1056 A’s, 958 B’s, and only 46 C's. This compared to an approximately symmetric distribution of 179 A's, 384 B's, and 221 C's among students taking the class in online sections. These differences prompted an analysis of the distribution of passing and failing grades to see if the significant difference was only a result of these extreme differences or also inherent in the passing and failing grades.

This further analysis showed no significant difference in the distribution of passing and failing grades, and there was also not a significant difference in the distribution of passing and failing grades when only those students who completed the course were considered. In addition, when students who withdrew from the course were included, there is also not a significant difference in the distribution of students who earned a credit between those who attempted the course via online or face-to-face methodology.

As in MAT 055, the relative impact of delivery methodology on a students' grades for traditional and non-traditional students was considered for MAT 065. Non-traditional students were 1.23 times more likely to earn a passing grade in face-to-face sections than were traditional students, but there were no other significant differences in the grade distributions for traditional or non-traditional students.

After considering the differences in student grades for traditional and non-traditional students, the relative impact of course delivery methodology was analyzed for full-time and part-time students. Full-time students were 1.19 times more likely to earn a passing grade in online versus face-to-face sections, but there was no significant difference identified for part-time students. When full-time and part-time students were compared with each other in face-to-face and online sections, full-time students were 1.60 times more likely to earn a passing grade than part-time students. This difference actually increased for online sections, and in these it was 1.82 times more likely for full-time students to earn a passing grade than part-time students.

Finally, the completion and retention rates for MAT 065 were examined based on course delivery methodology. There was neither a significant difference in the completion rate nor the retention rate for this course.

MAT 085. An initial analysis of the distribution of student grades for MAT 085 was conducted, and this analysis revealed a significant difference in the distribution of course grades. However, much like in MAT 065 and MAT 055, one reason for this difference is the dramatic difference in the distribution of passing grades. The grades in face-to-face sections were right-skewed, though not to the same magnitude as in the other courses. There were 341 A's, 398 B's, and 39 C's in face-to-face sections as compared to an approximately symmetric distribution of 90 A's, 173 B's, and 105 C's in online sections.

A significant difference remained between online and face-to-face sections in the distribution of passing and failing grades. This analysis showed that students were only 1.13 times more likely to earn a passing grade in online sections. However, accounting for students who withdrew, there was not a significant difference in the likelihood of a student earning a passing grade in the class regardless of the delivery methodology used by the course.

As in MAT 055, the distribution of passing and failing student grades was considered for only those students who completed the course. Among these students, the students who enrolled in an online section of MAT 065 were 1.55 times more likely to earn a passing grade than students who initially enrolled in a face-to-face section.

The relative impact of online versus face-to-face delivered courses was analyzed for traditional and non-traditional students. This analysis, though, did not reveal any significant difference. In a similar fashion, the relative impact of course delivery methodology was considered for full-time and part-time students. For part-time students, the grade distribution was significantly different between online and face-to-face sections. Part-time students were 1.47 times more likely to earn a passing grade in an online as compared to a face-to-face section. The other significant difference between full-time and part-time students occurred only in face-to-face courses in which full-time students were 1.67 times more likely to earn a passing grade than were part-time students.

When completion percentage for MAT 085 students was considered between those enrolled in online or face-to-face sections, it was found that students enrolled in face-to-face sections were 1.28 times more likely to complete the course than students enrolled in online sections. After analyzing the completion percentage, the retention rate was considered; however, there was not a significant difference in retention rate between online and face-to-face sections.

Finally, the persistence rate was measured using a random sample of those students who earned a passing grade in MAT 085. This analysis did show a significant difference in the persistence rate for students who earned a MAT 085 credit in an online as compared to a face-to-face section. In the random sample selected for this analysis, 60.8% of student who earned a MAT 085 credit in a face-to-face course persisted to earn a 100-level mathematics credit at SCC compared to only 30.0% of students who earned a MAT 085 credit in an online course.

Commonalities and Differences. The above analysis considered each remedial course at SCC separately, but there are also commonalities and differences among these courses. In all three courses, there was a significant difference in the distribution of course grades based on delivery methodology. An examination of the distribution of passing grades, though, for each course showed extreme differences in the distribution of A’s, B’s, and C’s. In face-to-face courses, these grades were strongly skewed with a mode grade of an A; however, for online courses the passing grades were more symmetric with a mode grade of B.

Subsequent analysis considering only the distribution of passing and failing grades continued to show a greater likelihood of student success in online courses for MAT 055 and MAT 085 and no significant difference in the distributions for MAT 065. When this sample was trimmed for only students who completed the course, the likelihood of success increased in the courses in which it was previously significant, and any difference remained insignificant in MAT 065.

When the relative impact of course delivery methodology was analyzed for traditional and non-traditional students, both groups performed significantly better in online courses than face-to-face courses in MAT 055. There was not a significant difference, though, between traditional or non-traditional student performance between online or face-to-face courses in MAT 065 or MAT 085. When non-traditional students were compared with traditional students, with the exception of traditional students out-performing non-traditional students in face-to-face sections of MAT 055, there was either no difference or the non-traditional students out-performed the traditional students in MAT 065 and MAT 085.

A similar analysis considering the relative impact of course delivery methodology on full-time and part-time students was also conducted. Both groups performed either equivalently or significantly better in online sections as compared to face-to-face sections in all three courses. Furthermore, other than in online sections of MAT 085 in which full-time and part-time student performed equivalently, full-time students consistently out-performed part-time students in all developmental mathematics courses.

While student achievement tended to improve in online sections, and there was no case in which student achievement was improved in face-to-face courses, examining the completion rate, retention rate, and persistence rate together paints a different picture. While there is no significant difference in completion percentage in MAT 055 or MAT 065, face-to-face students were more likely to complete the course than online students in MAT 085. Considering retention rate, MAT 065 and MAT 085 students did not have a significant difference in retention; however, students were significantly more likely to be retained to the next semester in MAT 055 face-to-face sections than in online sections. Finally, when persistence was measured among students who completed MAT 085, those students who earned a MAT 085 credit in an online section were less likely to ultimately earn a passing grade in a 100-level mathematics course at SCC.

Summary of Conclusions

This study is consistent with previous research which suggests that online remedial mathematics can be at least as effect as face-to-face delivery methodologies (Driscoll et al., 2012; Means et al., 2009; Nguyen, 2015). The relative effectiveness of online course delivery methodology on student achievement was greatest at the lowest level of remedial mathematics, but students in face-to-face sections did not out-perform students in online sections at any level of remedial mathematics in this study. Furthermore, this modest advantage in favor of online sections was maintained when comparing traditional and non-traditional students as well as full-time and part-time students. Considering only student achievement, online delivery methodologies were demonstrated to be at least as effective as traditional delivery methodologies for community college remedial mathematics courses. It should be noted that, consistent with the work of Ashby et al. (2011), relative student achievement did move positively in the direction of students enrolled in online sections of remedial mathematics when only students who completed the course were considered.

Successful completion of any course is the result of the interaction of numerous variables, so it is difficult to determine the most critical factors for student success. However, based on previous research and personal experiences teaching remedial mathematics students, the researcher hypothesizes that these positive outcomes in favor of online delivered remedial mathematics courses are possibly the result of the individualized instruction provided in online instruction environments. Students come to remedial mathematics courses with various strengths and weaknesses, and individualized learning opportunities allow a student to invest his or her learning time on identified weaknesses while skipping topics that have already been mastered. In traditionally delivered mathematics courses, the entire class moves through the material at a uniform rate, which is prescribed by the instructor. This individualization advantage is particularly true in the lowest levels of developmental mathematics since the topics of such courses are more skill-based, such as operations with integers, than concept-based. Furthermore, these advantages for all students increase for non-traditional and part-time students who often experience the greatest advantage from the flexible schedule of online courses.

The non-grade based concerns of completion percentage, retention rate, and persistence paint a less favorable picture for online remedial mathematics courses. The overall completion percentage either showed no significant difference or was significantly higher for face-to-face sections. Similarly, retention rate was either not significantly different or was significantly different in favor of traditionally delivered courses. This is consistent with previous research which also showed that the differences were modest (Ashby et al., 2011; Fike & Fike, 2008; Peterson & Bond, 2004; Wolfle, 2012).

The researcher hypothesizes that these results are likely the result of a combination of academic and social factors. Students in remedial mathematics courses, by definition, have not been successful in previous mathematics courses. As such, remedial mathematics students often have a fear of the discipline as well as a lack of mathematical self-efficacy, which can result in low completion rates. Face-to-face students, however, may have an advantage over online students because of the opportunity to develop a personal relationship with the instructor or fellow students. These relationships can help to mitigate other factors that decrease completion and retention rates.

Finally, the ultimate goal of remedial mathematics is to prepare students to successfully earn a credit in a college-level mathematics course. Previous research showed a low overall success rate in achieving this goal, so educational leaders are interested in determining ways to improve this success rate (Bailey et al., 2010; Benken et al., 2015; Wolfle, 2012). This study showed that students who earned a MAT 085 credit in an online course had a significantly lower probability of ultimately earning a college-level mathematics credit. The researcher believes that this may be evidence that face-to-face students develop a deeper understanding of the mathematical content than online students, but other explanations are also possible. One such alternative explanation to be considered is the delivery methodology of the college-level mathematics courses. If students are not given the same opportunities for online instruction in their non-remedial mathematics courses, then students who have been successful in online remedial mathematics courses may have difficulties transitioning back to traditionally delivered courses.

The results of this study lead the researcher to conclude, similar to Lack (2013), that educational leaders should be cautiously optimistic in offering online sections of remedial mathematics. These courses can offer at least equivalent educational opportunities to students who may, for a variety of reasons, be unable to attend traditionally delivered classes. However, there are risk factors surrounding student completion, retention, and persistence which need to be considered and, if possible, mitigated.

Limitations

There are some limitations to the generalizability of this study to be considered. These include the narrowly selected population, the type of data that were available, and the limitations of the particular statistical tests used in the analysis. An obvious limitation in this study is the narrow population resulting from a singular focus on remedial mathematics courses at SCC. The primary aim of this study was to consider the relative effectiveness of course delivery methodology, so the study focused on a single community college in order to separate course delivery methodology from other factors such as curriculum or demographics. The data provided did not identify the particular curriculum or learning management software used in a course, but these variables are consistent at a single community college during a single semester.

Because the aim of this study was to consider the relative effectiveness of course delivery methodology on remedial mathematics, it was important to utilize data from several academic semesters. This required, however, the use of historical data since this study could not feasibly track students across multiple years. The historical data available for this study did not allow for any examination of particular assessments, such as scores on the final exam or attendance data beyond a failing student's final date of attendance. In addition, the last date of attendance data were missing for some of the students who failed a course, and this influenced some of the definitions of concepts analyzed, including retention and persistence, in this study.

The missing last dates of attendance in the data are the result of instructor error. This error suggests that there may be a difference in the level of training received by the course instructors of the remedial mathematics courses at SCC. While the instructor pool is relatively small at a single community college, there was not a control in this study for the course instructor or the level of training received by the instructor prior to the course.

Finally, the analysis in this study uses Chi-square tests as well as Z-tests for the difference in proportions. Such analysis is appropriate for revealing a statistically significant difference in two groups; however, such analysis does not allow for an understanding of the factors contributing to these differences. In this way, this study exists as an initial analysis revealing questions for future study for educational leaders desiring to most effectively teach community college remedial mathematics students.

Recommendations

The findings of this study raised questions which may be pursued by other researchers with other studies as well as suggests recommendations for community college leaders.

1. The extreme differences in the distribution of passing grades observed between online and traditionally delivered sections of remedial mathematics courses raise a variety of questions. What factors contribute to the observed differences in the distributions? Do face-to-face students who pass a course master more content and thus earn more high passing grades? Do personal relationships which develop between students and instructors in face-to-face settings impact student grading? Such questions are outside the scope of this study based on the type of data obtained.
2. Are the differences in student persistence to earn a 100-level mathematics credit demonstrated in this study the result of a higher quality of mathematics remediation face-to-face or other factors? If it is a result of other factors, what are these factors and how can they be addressed?

3. Educational leaders should consider the challenges posed by non-academic issues for online remedial mathematics students, such as low mathematical self-efficacy, socio-economic status, or student connection to the campus community, and the impact of these issues on student completion and retention rates. What types of non-academic interventions could be made to improve student completion rate and retention rate in online courses?
4. Because successful online students tend to be self-regulated learners, and remedial mathematics students are often not self-regulated, should community college leaders require a training course teaching students how to be successful in online mathematics courses before allowing students to enroll in online sections of remedial mathematics?

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Appendix A

Institutional Review Board Approval Letters

MURRAY STATE
UNIVERSITY

Institutional Review Board

328 Wells Hall
Murray, KY 42071-3318
270-809-2916• msu.irb@murraystate.edu

TO: Randal Wilson
College of Education and Human Services

FROM: Institutional Review Board
Jonathan Baskin, IRB Coordinator

DATE: November 29, 2016

RE: IRB # OFD 17-09

Determination: Individuals not Identifiable - Activity does not involve human subjects as defined in 45 CFR 46.102(f)(2)

The MSU IRB has reviewed your student's application entitled, *An Analysis of Learning Outcomes, Retention, and Persistence in Developmental Mathematics Courses Based on Delivery Methodology.* Based on the information supplied on this application, it has been determined that your student's project does not involve activities and/or subjects that would require IRB review and oversight. Your IRB application will be kept on file in the IRB office for a period of 3 years.

Please note that there may be other Federal, State, or local laws and/or regulations that may apply to your project and any changes to the subjects, intent, or methodology of your project could change this determination. You are responsible for informing the IRB of any such changes so that an updated determination can be made. If you have any questions or require guidance, please contact the IRB Coordinator for assistance.

Thank you for providing information concerning your student's project.

Opportunity *afforded*

murraystate.edu

300 North Main Street
Versailles, KY 40383
(859) 256-3100
Website: kctcs.edu

12/15/2016

John Eveland
110 Woodhill Rd.
Bardstown, KY 40004

RE: An Analysis of Student Learning Outcomes, Retention, and Persistence in Developmental Mathematics Course Based on Delivery Methodology: Research Protocol

Dear John:

After careful consideration of your application to the KCTCS Human Subjects Review Board, I have determined that you are eligible for exemption from federal regulations regarding the protection of human subjects based on your research using a procedure that meets the exempt review criteria section 7 (2).

Thank you for your cooperation in meeting the federal requirements for conducting research that utilizes human subjects. We appreciate your notification to this board and we will keep your information on file.

Sincerely,

Rhonda R. Tracy, Ph.D.
KCTCS Chancellor

Pamela M. Duncan
Associate General Counsel
Chair, KCTCS Human Subjects Review Board

cc: Alicia Crouch
Vice Chancellor of Research & Policy Analysis